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HIGH ENERGY STORAGE FLYWHEEL TEST PROGRAM.(U)
JAN 80 D R HODSON DAAG53-78-C-0278
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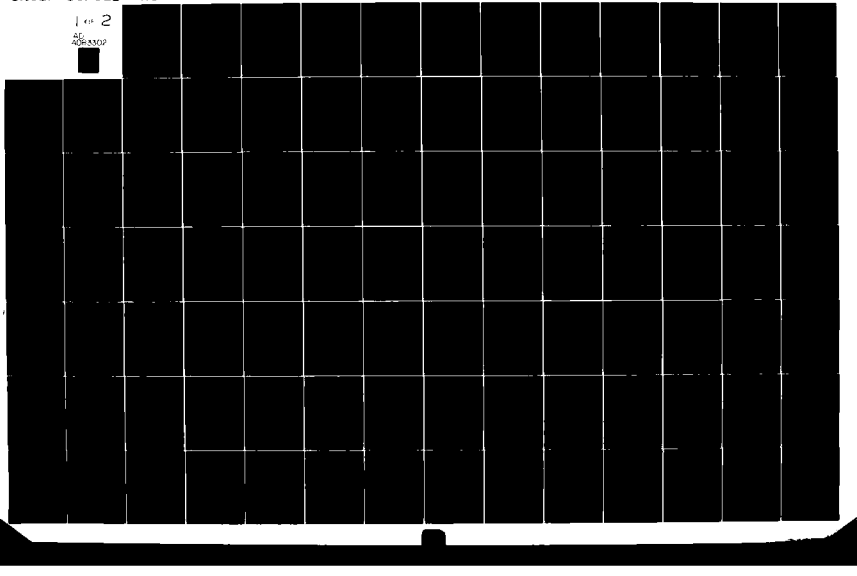

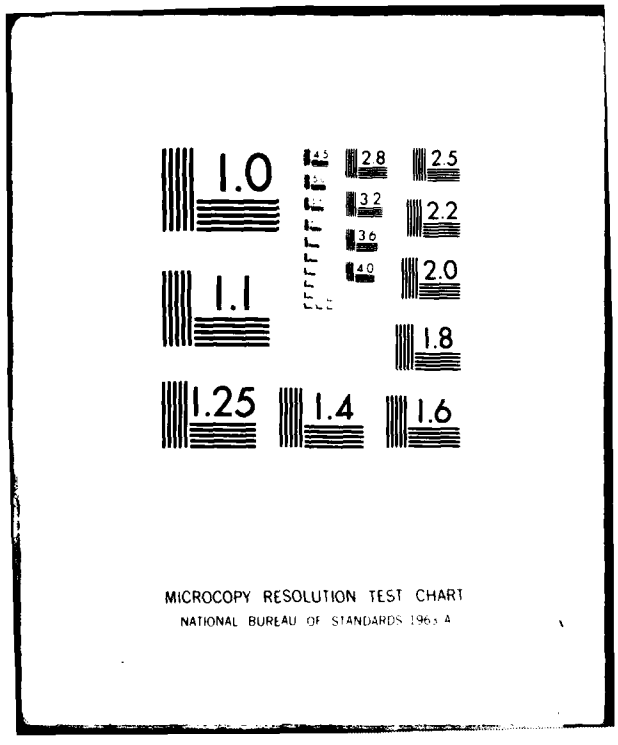
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ROCKETDYNE
REPORT NO. RI/RD78-207-1

REPORT OF TEST ON: RS-31 FLYWHEEL SYSTEM

TEST PERFORMED BY:

ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL

TEST AUTHORIZED BY:

U. S. ARMY - MERADCOM

28 JANUARY 1980

UNIVERSAL
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REPORT NO. RI/RD78-207-1

REVISION NO. _____

REPORT OF TEST ON: RS-31 FLYWHEEL SYSTEM

The RS-31 Flywheel System is an energy storage device which is accelerated by an AVCO LYCOMING T55-L-7C 2930 SHP drive engine to 14,506 RPM. The two contra-rotating double disk rotors of the flywheel module have an inertia of 320,176 in²-lbs storing 30 KW-HRS of energy at design speed. This was a Research & Development test activity designed to explore and verify design predictions of system performance.

TESTING WAS INITIATED ON 10 SEPTEMBER 1979

TESTING WAS COMPLETED ON 29 NOVEMBER 1979

THIS REPORT WAS WRITTEN BY:

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RS-31 FLYWHEEL SYSTEM TESTING REPORT

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FACTUAL DATA

1.0 DESCRIPTION OF SYSTEM

The RS-31, as shown in Fig. 1, is a flywheel energy storage system rated at 30 KWH (40 HP-HR) at 14,506 rpm. Accelerating power is supplied by an AVCO gas turbine engine rated at 3000 HP in this application. The decelerating load consists of a pair of Bendix high voltage generators. The load path is from the gas turbine into a four-in-line 1-to-1 ratio gearbox which serves to deliver counter-rotational power to a pair of horizontally aligned parallel flywheel rotors through a pair of sprag-type over-running clutches. At the far end, stored power is absorbed by the directly coupled generators upon electrical command.

Auxiliary controls and instrumentation are included as part of the RS-31 system providing a completely self-sufficient means for evaluation, lubrication, temperature control, speed control and diagnostic data.

The heart of the RS-31 system is its set of flywheel rotors which are machined and assembled from vacuum-melt, forged and heat-treated low nickel alloy steel HP 9-4-30. Each rotor consists of a pair of end stub shafts and a pair of 37.1 inch diameter discs all of which are flanged and bolted together without the concession of disruptive center disc through-holes. The rotor discs are formed by combining the profile of an infinitely tapered equalized stress disc with an outer rim which improves inertia and stress distribution for limited diametral envelopes.

The assembled rotors (with all shaft rotating elements installed) are each balanced to less than 15 gm-in residual unbalance and mounted horizontally within a casing which also supports the gearbox, gas turbine and generators. Out of consideration for the spatial envelope specified for the RS-31 installation, the casing assembly was designed for an offset placement of the parallel rotors so as to nest the righthand rotor disc pair slightly forward and inside of the diametral envelope of the lefthand rotor discs.

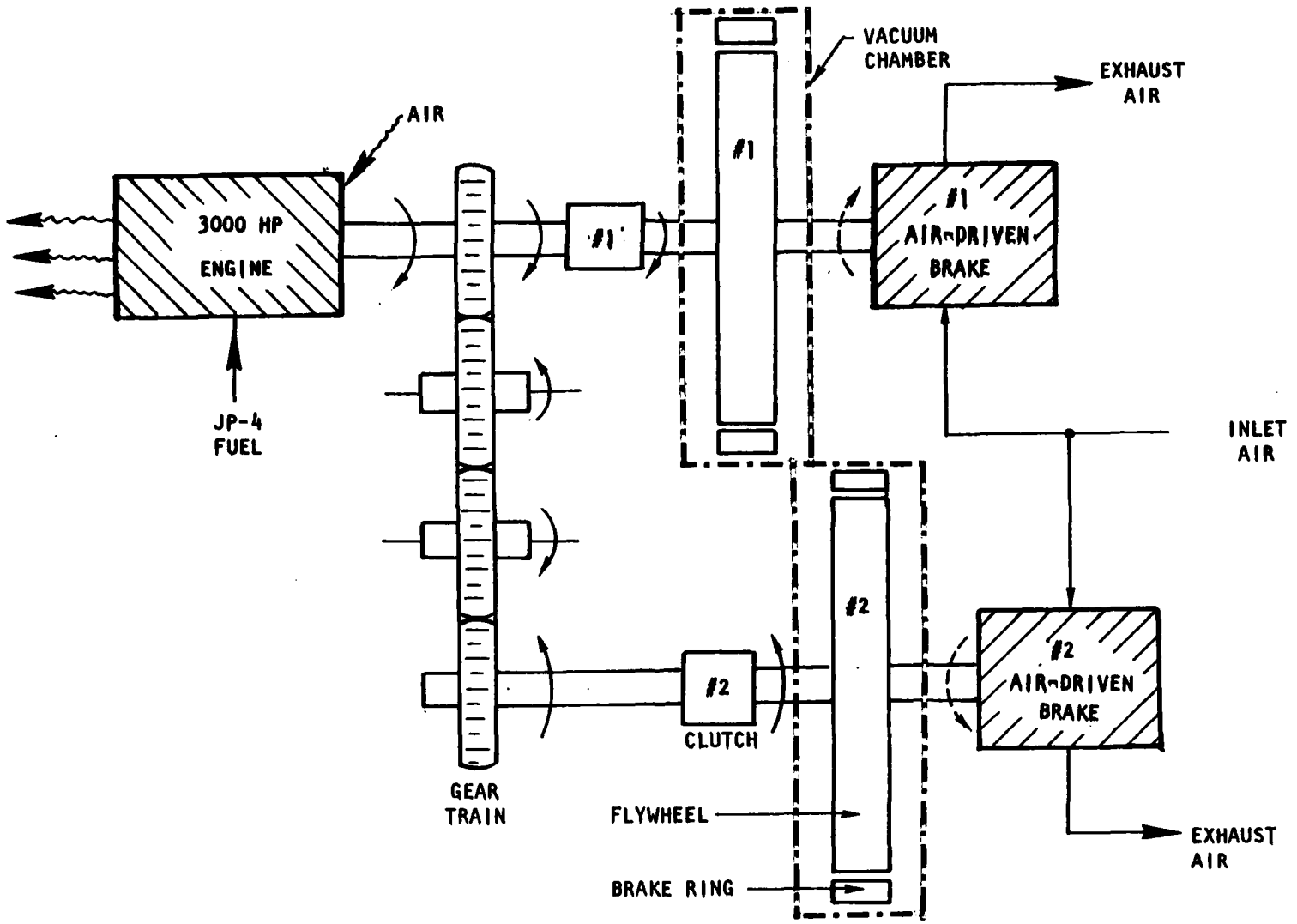


Figure 1. RS-31 Flywheel System Test Configuration

Three 356-T6 cast aluminum alloy case sections are used to house the two flywheel rotors and their supporting components. The castings are impregnated to reduce their porosity as vacuum chamber sections. Each rotor sits within an independently sealed vacuum chamber and is surrounded by a set of 4340 steel barrier rings which are supported by low dialectric fiberglass pilot rings so as to be electrically isolated from the case and rotor structure. The barrier rings, in addition to serving as overstress limit devices, also are used as part of a rotor strain detection diagnostic system in conjunction with the instrumentation package. Each ring is approximately 3" wide in the axial direction, and is centered at the planar centerline of its mating rotor disc. A pair of spring loaded insulator plates between the barrier rings in each vacuum chamber serve to hold the rings firmly in place on their pilot rings. A set of windows are located in the case walls allowing visual and physical access to the rotor/barrier ring interface.

The forward end of each rotor is supported by a duplex pair of 80 mm oil jet lubricated opposed angular contact ball bearings which fix the axial freedom of the rotor. The aft end of each rotor is supported by a single 80 mm roller bearing which provides rotor axial freedom to compensate for thermal and poisson effects. A set of spring loading carbon-lip dynamic shaft seals are used between the bearing stations and the rotor vacuum chamber. Steel liners are used to support the bearings and seals within the aluminum case assembly with a pair of concentric liners located at each of the two forward and aft stations. Each outside liner supports and positions one shaft seal assembly and acts as the outer wall of a rotor vibration damping reservoir. The inner liner supports and positions the bearings and provides the inner wall of the damping reservoir. Oil passing radially inward (to lubricate the bearings and seals) spreads into this reservoir as the viscous damping media. Both liners are flanged at their outside ends, but while the outside liner is also piloted on the case wall at its inboard end, the inner liner is spring cantilevered from the end to reduce the rigidity of the bearing cage allowing the rotors to spin about their true axial centers of gravity. Thus, rotational vibration of the flywheel assembly is not transmitted directly to the case structure.

At the aft end of each rotor a shaft mounted sprag clutch allows the flywheels to be accelerated but when the driver speed is reduced below flywheel speed, the sprags disengage allowing each rotor to spin freely and independent of the driver. A pair of 65 mm ball bearings on either side of each sprag clutch cage serves to separate the inner and outer clutch cylinders. The inner cylinder is splined to the rotor shaft while the outer cylinder pilots the female end of the splined drive shafts.

The aft case of the RS-31 module serves as a central oil collection and distribution center for lubricating oil. One section of the case collects oil from the forward end (externally scavenged), from the aft end by natural drainage and from the gearbox by natural drainage. This oil drains through an internal dearation screen and is piped away for straining and cooling as required. Returning oil is pumped into a sump section of the aft case where a heater allows control of viscosity before the oil is pumped through filters to the bearings, gears, seals and splines.

The AVCO gas turbine bolts to the aft end of the module on the left side of the gearbox and turns clockwise. A splined shaft between the turbine and far left gear of the gearbox delivers drive power to the geartrain. A second shaft which fits into the forward half of this left side gear delivers power directly to the left rotor clutch outer cylinder. Power to the right side rotor is delivered through the four gears of the box so that the right end gear turns counter clockwise. A third shaft delivers power from this gear to the right rotor clutch outer cylinder. The nested rotor centerlines are separated by 28 inches.

A set of eight control packages regulate and monitor module operation. Five of these are standard 19" wide rack panels whose functions are gas turbine control, signal conditioning, limit-alarm processing, power breaker relay functions, and the main operator control and display panel. These five panels are mounted in a standard electrical cabinet. The other three control subassemblies are compact skid mounted units whose functions are oil pumping,

oil scavenging and evacuation and oil cooling. The control system is designed to use 208 volt, three-phase 400 Hz power. A pair of 5.7 HP motors are used to power the oil and vacuum pumps and a pair of 1.0 HP motor driven fans force air through the oil cooler at 2,000 CFM.

The vacuum pump is rated at about 4.5 CFM at 1 TORR. Separate 10 micron filters are provided in each of the three oil delivery mains to forward, aft and gearbox oil jets. These are preceded by magnetic separators and strainers at the sump discharge. An oil level switch in the sump and oil pressure switches in the line as well as dirt alarm switches at the filters allow the operator to be advised of discrepant conditions. Oil supply temperature is automatically regulated at 150°F at all times. The operator's control and display panel provides continuous reading digital display of individual rotor speeds, disc centrifugal and thermal radial growth, case vibration levels, individual chamber vacuum pressure and primary oil parameters as well as alarm lites for several secondary parameters.

Gas turbine and gearbox speed are displayed at the turbine control panel along with turbine exhaust temperature and engine torque.

2.0 DESCRIPTION OF TEST INSTALLATION

The RS-31 system was tested at Building 252, the D185-109 Hydraulics Laboratory (see Fig. 2) of the North American Aircraft Division (El Segundo Function) of Rockwell International. The deliverable control consoles were located within Building 252, near the facility controls and data center, approximately 30 feet from the outer west wall of the building. The module and supporting subsystems were placed in a newly constructed test cell located about 15 feet outside of the west wall of Building 252. The test cell was about 15' x 25' in size (internally) with walls constructed of 1/2" steel about 8' high, lined with 18" of railroad ties stacked horizontally and held by a steel skeletal frame to the outer shell which was in turn supported by steel I-beam structure. A steel skeleton frame was placed overhead with corrugated plastic panel roofing. A single mazeway entrance at the east end of the cell was provided for personnel access and the entire west wall was removable by fork-lift for major hardware access.

The module was bolted to the cell floor with rotor axis in the east-west orientation with the gas turbine at the west face. The turbine exhaust was pointed due west through a large diameter duct in the removable wall. The lubrication and evacuation subsystems were bolted to the floor in the southeast corner of the room. Large facility pipes and valves (1.5" to 8" diameter) were located at the east end of the cell to deliver facility air to drive the air turbine brakes, to provide low pressure brake exhaust (upward) and to provide for air brake evacuation capability. A mobile 400 Hz generator cart was located between the cell and the building and a JP-4 fuel tank was installed outside the south wall of the cell to serve the gas turbine driver engine. Facility lube-oil systems located inside the west wall of Building 252 were delivered to the cell by overhead pipe for brake lubrication.

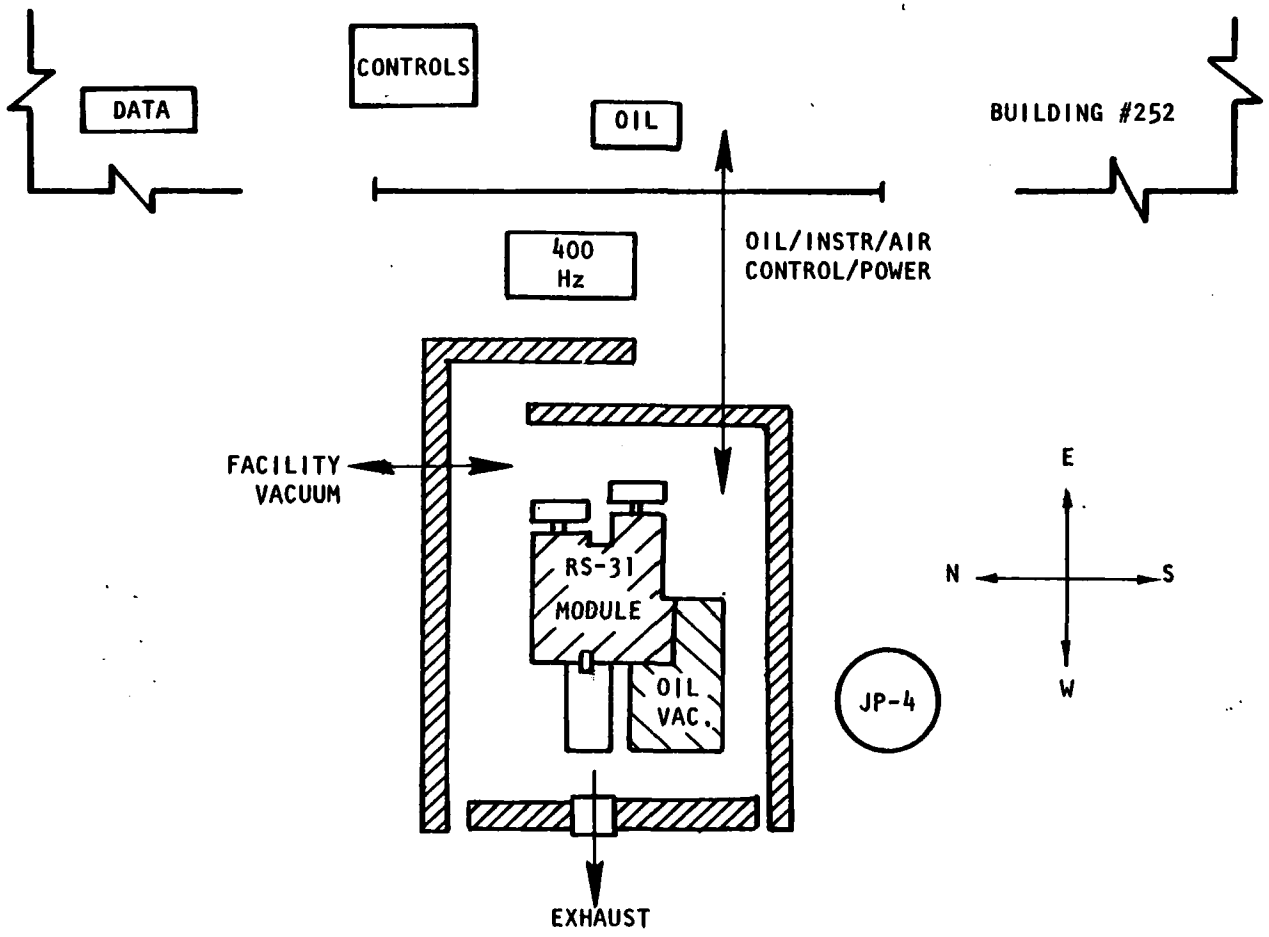


Figure 2, RS-31 Test Facility

3.0 TEST PLAN

The plan for test of the RS-31 system was initially detailed in test specification RC-1290 (pages 103-145 of final report RI/RD78-207) released to MERADCOM 30 May 1978. Subsequently, the test plan was revised as noted in monthly reports and herein, however, essentially all elements of the initial plan were either performed or expanded. The initial test plan is shown by Figs. 3 and 4 with comments hereafter to define adjustments and reasons thereto.

Test A was exchanged with Test B to check out flywheel rotation at lower speeds than practical with the gas turbine and to take into account revisions in the plan for initial gas turbine operation which was to have been gas turbine only (note speed target of 15,000 rpm in the prior Test A plan). This revision enhanced the program in two ways:

1. More cautious and precise initial spin-up of the flywheel;
2. More complete system-oriented test when the gas turbine was activated.

Test C was then conducted essentially as planned. Based on the early success with Test C, the plan for - - -

Test D was expanded to nearly twice the earlier target speed.

Test E was also expanded as a consequence of the test progress to date achieving 13,400 rpm rather than 11,000 rpm.

Test F was divided into two parts but adjusted in top speed to 14,850 rpm (was 15,000 rpm) as a consequence of the higher energy storage performance for rpm than originally targeted. Thus, the target energy level of 30 KW-HRS was achieved at a rated speed of 14,506 rpm (see final report) and an overspeed point of 14,850 rpm was also demonstrated.

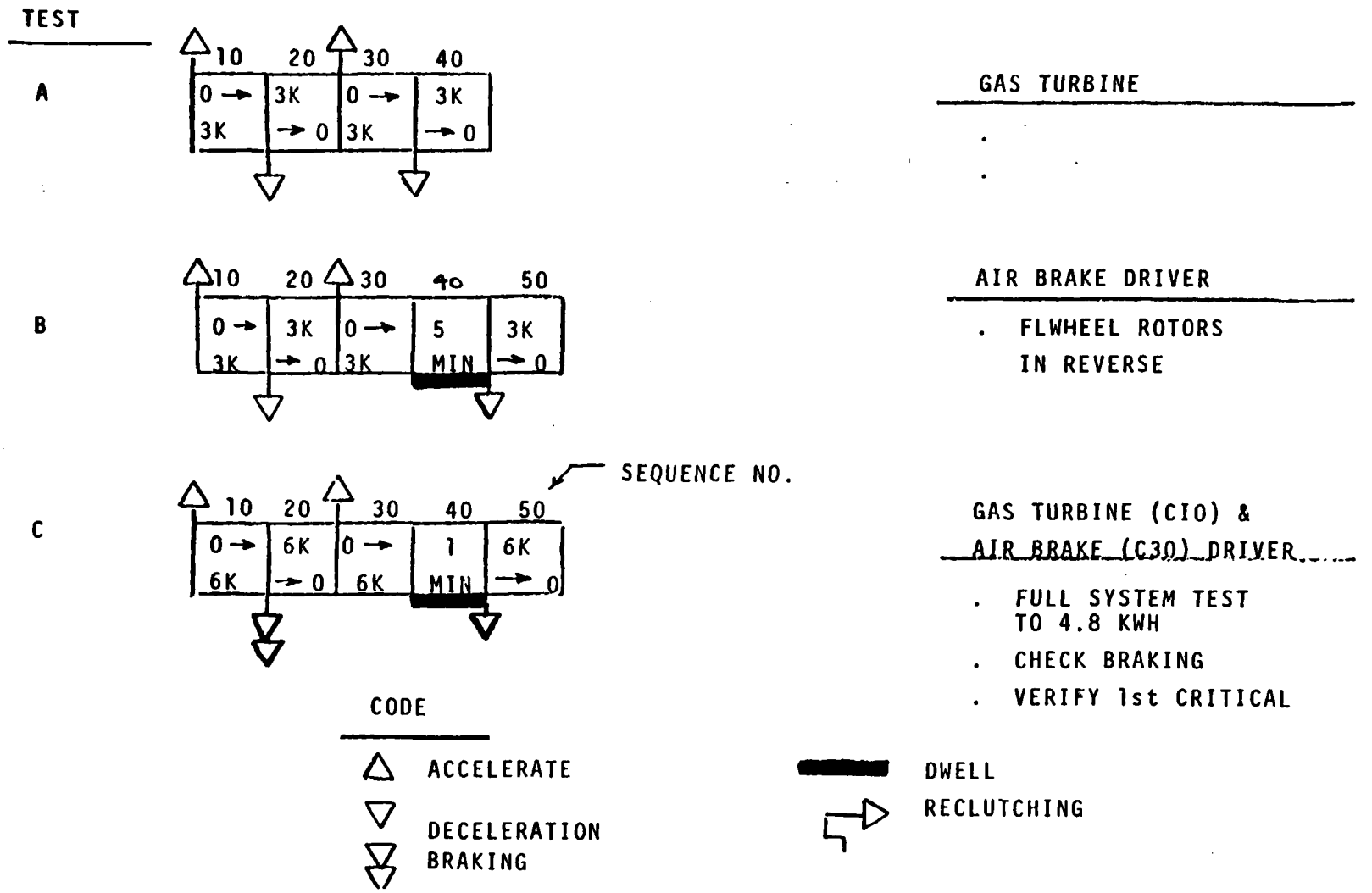
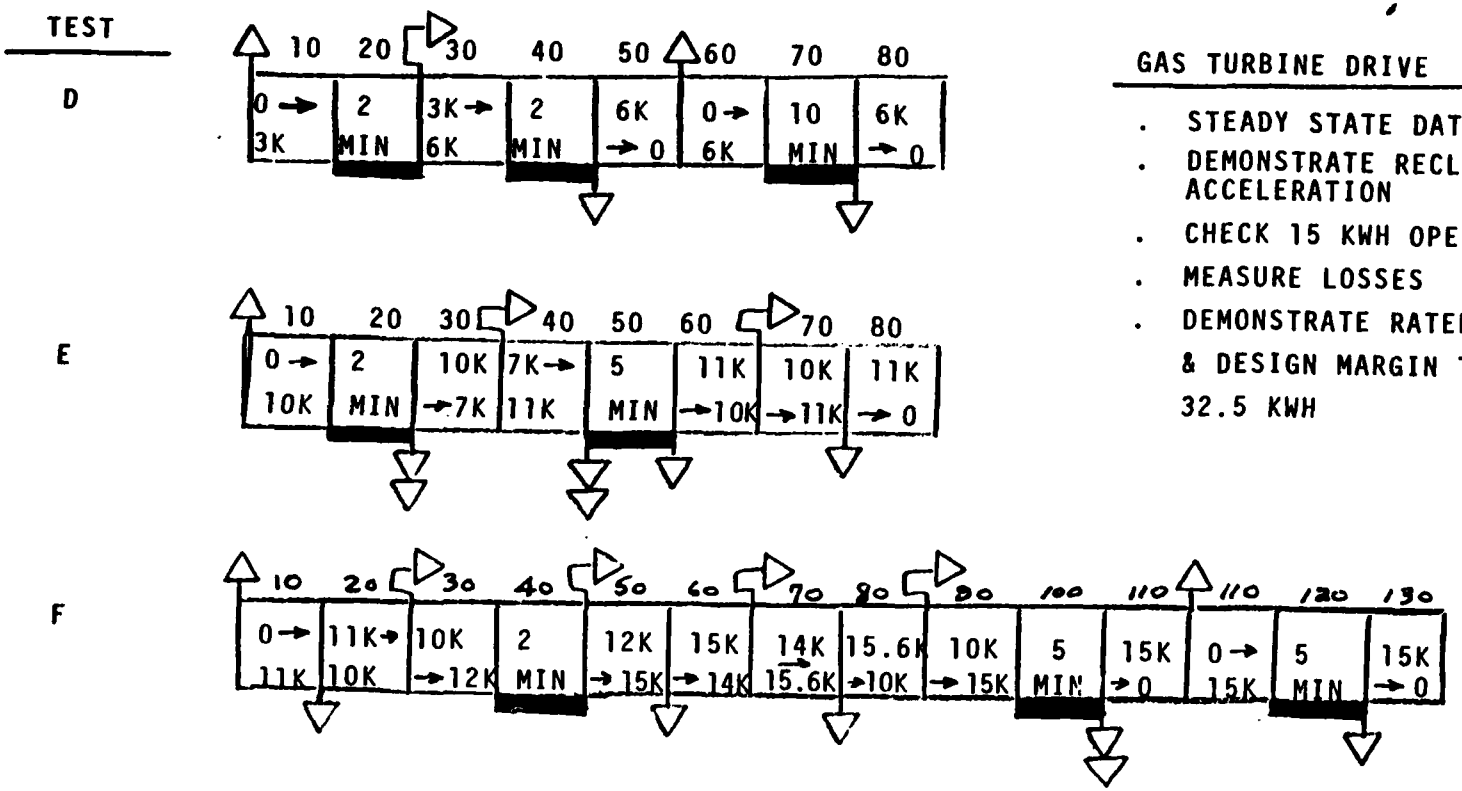


Figure 3. RS-31 Test Sequence



GAS TURBINE DRIVE

- STEADY STATE DATA
- DEMONSTRATE RECLUTCHING ACCELERATION
- CHECK 15 KWH OPERATION
- MEASURE LOSSES
- DEMONSTRATE RATED SPEED & DESIGN MARGIN TO 32.5 KWH

Figure 4. Test Sequence (continued)

4.0 TEST PROCEDURES*

Tests of the RS-31 system were conducted utilizing the deliverable console as well as a facility systems console to control brake and facility oil operations.

Pre-Test Conditions

a) Lube oil supply system shall be leak tight, filled with MIL-L-23699B oil, calibrated for proper valve and switch settings and off.

b) Module rotor chamber should be drained free of oil and evacuated.

c) Console power switches shall be ON for at least 3 hours to stabilize instrumentation, and all system controls shall be OFF.

d) Engine throttle positions shall be set, fuel shall be provided to engine and battery capacity verified.

e) Module data channels shall be calibrated and Switch S9 set to display data.

*Note: Some detail figures and charts for test procedures are not available for reproduction and have been deleted herein.

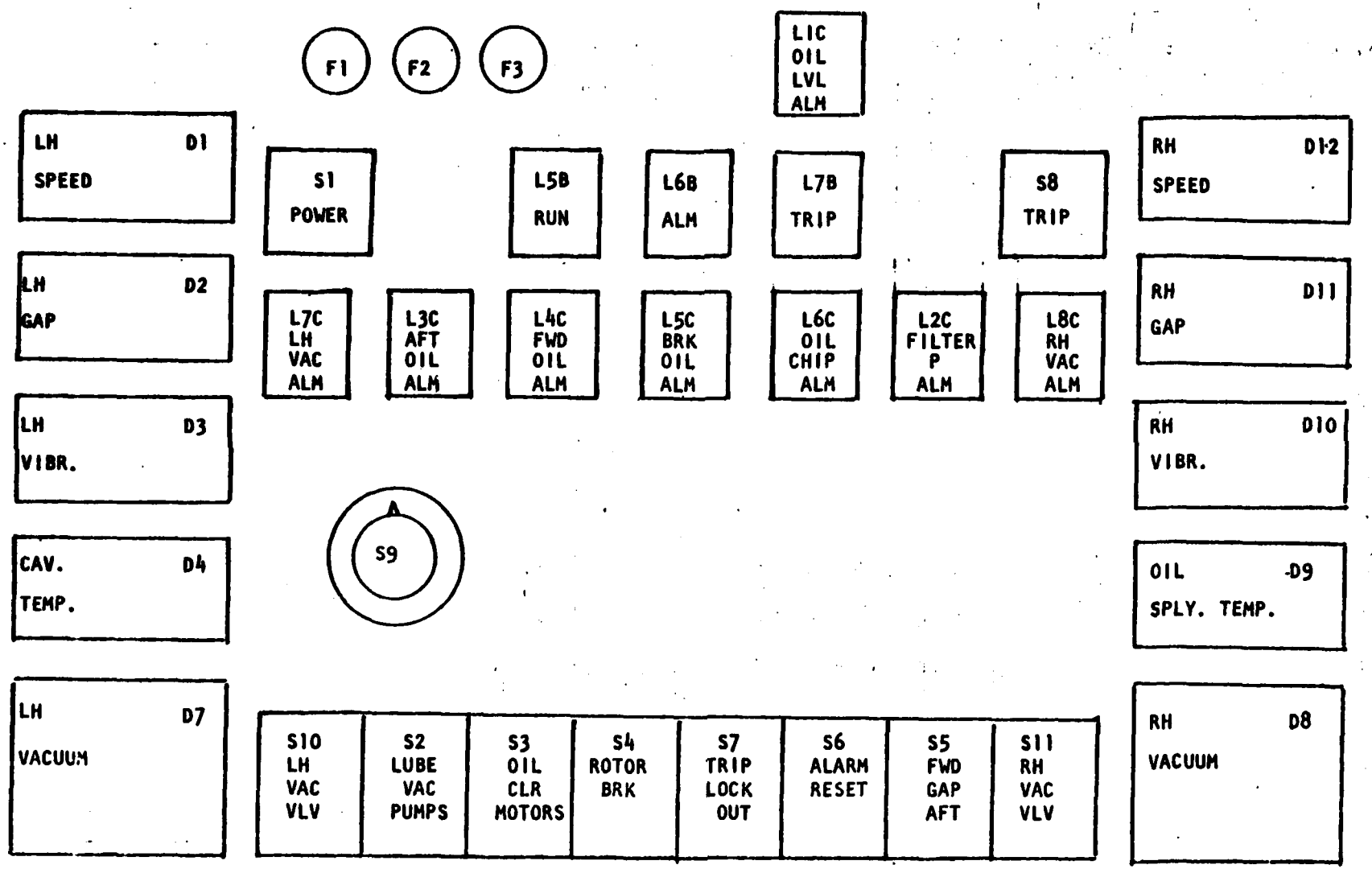


Figure 5 OPERATORS CONTROL PANEL

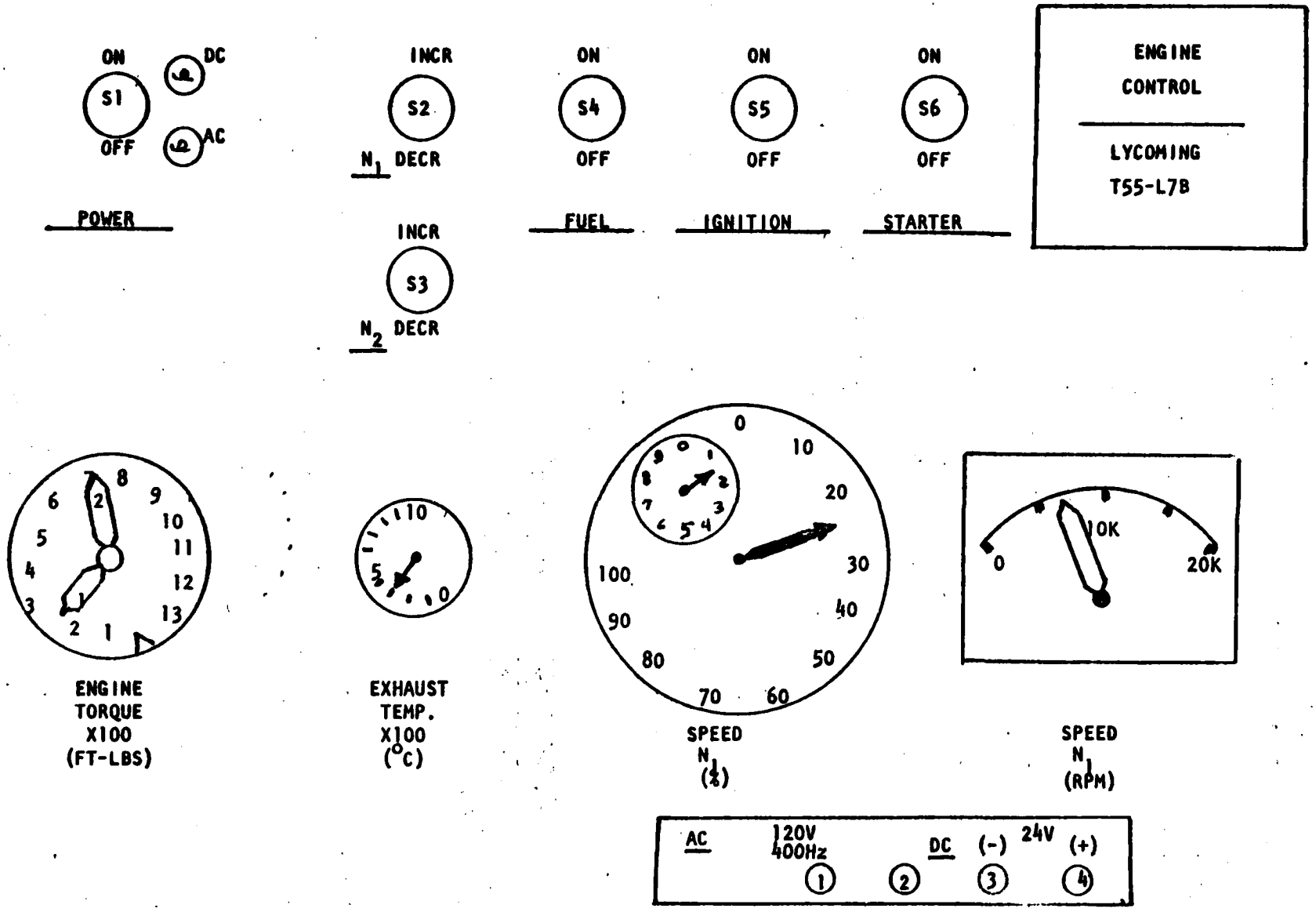


Figure. 6 ENGINE CONTROL PANEL

Activation

a) Turn on module oil and vacuum system switches S2 (lube and vacuum), S3 (oil cooler fans), and S10/S11 (vacuum valves).

b) Verify oil system operation and reset alarms with switch S6.

c) Turn the engine ON using switches S1 (power), S6 (starter), S4 (fuel), and S5 (ignition).

d) When engine exhaust temperature reaches 700C, turn switch S5 (ignition) OFF.

When engine speed N_1 reaches 60%, turn switch S6 (starter) OFF.

e) Use switch S2 (N_1) to control system acceleration to target speed.

Shutoff

a) Turn engine switch S4 (fuel) OFF

b) When flywheel rotation has stopped, turn off lube oil and vacuum system (module switches S2, S3, S10, S11).

4.1 TEST REQUEST RS-31 FLYWHEEL TEST A

4.1.1 Introduction

Specification RC1290 in Report RI/RD78-207 gives requirements for six tests of the RS-31 flywheel. In view of problems which surfaced during facility preparation, some changes in the test hardware and order were made. This request will bring the test requirements up-to-date for performance of Test A. It will be supplemented by additional Test Requests for the following tests.

The test described here is a blowdown using the brakes to drive the flywheels slowly backward. This was called Test B previously. The jet engine checkout test will be called Test B.

4.1.2 Test Objectives

Test A will be a preliminary checkout of the flywheel assembly without the jet engine, using the air brake turbines to drive the flywheels. Objectives are:

a. Calibrate and checkout all lubrication and air systems.
b. Demonstrate facility operation.
c. Seat the four RES1284 seals and draw a vacuum in both left and right cavities.
d. Try to operate and calibrate the LF Gap Sensor.
e. Develop operating procedures and data reduction under safe conditions.
f. Final test readiness check of LE76-030-ER Flywheel.

4.1.3 Hardware to Be Tested

LE76-030-ER	Flywheel Assembly
LE76-224-ER	Flywheel Brake - LH
LE76-225-ER	Flywheel Brake - RH
LE76-031-ER	System Test Interconnect
LE76-071-ER	RS-31 Mechanical Diagrams

The flywheel assembly is complete, except for two problems. First, cavity vacuum cannot be obtained due to the RS1284 seals being unseated. They are expected to seat with shaft rotation, aided by alternate vacuum and pressure. Secondly, the left front gap sensor is grounded and inoperative. It is hoped that drawing a vacuum in the case and spinning the flywheels will dislodge or dry out whatever is causing the short circuit.

The lube system must be calibrated before test, as requested in EWR388154, and the relief valves set for low speed operation.

Instrumentation will be limited as requested in EWR388157, plus omission of all engine instruments.

4.1.4 Facility

The test facility at the Hydro-Mechanical Laboratory will be used. Group 185-109 will perform the tests in the special test cell outside Building 252.

Figure shows the complete oil flow schematic, both facility and flywheel units. The air and vacuum schematics will be as shown on LE76-071-ER.

The complete instrumentation list is attached, with instruments not needed for this preliminary test lined out and extra instruments required for this test listed on Sheet . An "X" shows where a channel is required, but has not been assigned as of this writing.

4.1.5 Safety

Every effort will be made to insure safety for this test. Procedures will be based on slow speed operation, to insure minimum damage by any malfunction or procedural error. The flywheel will be accelerated in 500 rpm steps, based on low speed tachometer attached at the engine pad. No acceleration will be attempted until all bearings indicate proper operation and all pressures are acceptable for the next higher speed. All operations will be remote with no

personnel exposed to any flywheel, air or lube system failures during the run. The facility lube system backup will be tested and operating. Top speed of 3000 rpm will be approached but not exceeded until all instruments have been surveyed for possible trouble and good control has been demonstrated at each lower speed.

4.1.6 Test Procedure

When facility checkouts are complete and a Test Readiness Review has been approved, the test may be started.

a. Check all facility and test systems for oil level, air supply, power supplies and instrument responses. If any alarm lights are inoperative, a redline of that instrument will be established, with redline observer fully instructed. Open brake exhaust valve.

b. Turn on oil heater and obtain proper oil temperature. Turn on module and facility lube systems and verify all temperatures and flows.

c. Pressurize module cavities until seals seat and turn off pressurizing gas supply. Leave vacuum valves closed, so module cavities are under a slight (1 to 5 psig) pressure.

d. Open brake pressure valve and apply 120 psi air to brakes. On reaching the first indication of motion, stop the air flow and check to see that the gearbox pump is primed and operating. Continue slow speed (below 200 rpm), until the gearbox lube system is fully primed and operating. If any problem appears, allow the system to drift to a stop and investigate.

e. If everything is within redlines, apply 120 psi brake pressure until 500 rpm is reached. Allow flywheels to drift while all instruments are checked. After two minutes, open the vacuum valves and see if a vacuum is obtained. If not, reseat the seals with 2 to 5 psi pressure and continue. If a problem is observed, allow the flywheels to drift to a stop, then investigate.

f. Apply 120 psi brake pressure until a speed of 1000 rpm is reached. Check instrument readings and seal seating as before.

g. Increase speed in 500 rpm increments to 1500, 2000, and 2500 rpm if all indications are satisfactory. Allow the flywheel to drift to a stop from 2500 rpm. Check for seated seals and check the LF gap sensor. If no vacuum is obtained, terminate the test for seal repairs.

h. Check all oil levels and possible lubrication or other problem areas. Repair or fix any problems.

i. Restart under 120 psi air pressure and accelerate smoothly to 2000 rpm. Allow flywheels to drift while all instruments are checked. If satisfactory, accelerate to 3000 rpm and hold speed for 5 minutes.

j. Reduce data and compare with expected performance. If all parameters are within acceptable limits, proceed to Test B.

4.2 TEST REQUEST RS-31 FLYWHEEL TEST B

4.2.1 Introduction

This test request describes tests required to meet a changed definition of Test B of Specification RC1290. This test will be run at the Aerospace Laboratories in the facility which recently ran Test A to the Test Request from the writer to T. Oppenheim, dated 5 September 1979.

The original Test B (actually called Test A in Specification RC1290) was to run the Lycoming jet engine only, not connected to the flywheel. Mr. D. Hodson has changed the requirement at the Army's request, to require that the drive shaft be installed to prevent overspeed of the jet engine power shaft, so there will be rotation of theflywheel. The speed of the flywheel will be kept below 3000 rpm at all times by shutting down the jet engine any time this may become necessary. As a consequence, the jet speeds will be limited.

4.2.2 Test Objectives

The test is to be run before new seals can be installed on the brakes, so there will be a minimum of oil flow to the brakes, to prevent excessive loss of oil. The lubrication system will otherwise be the same as was used during Test A. No brake vacuum will be used and brake air flow will be used only in an emergency. The main shaft seals are now seated and sealing, so no oil loss through the module is expected. Vacuum will be maintained in the module and the seals will be tested in this run. A redline on module vacuum will prevent excessive loss of oil, if the seals fail.

The major objective is to demonstrate that the jet engine is properly mounted and operating, as well as to find out how much flywheel acceleration is caused by the idling jet.

4.2.3 Hardware to Be Tested

Same as Test Request of 5 September 1979, essentially consisting of an RS-31 flywheel assembly. In addition, the Lycoming T55-L-7C engine will be installed with its exhaust and fuel supply systems.

4.2.4 Facility

The Hydro-Mechanical Laboratory test cell outside Building 252. Operation will be by D/185-109 personnel. Instrumentation will be according to the attached list. The jet engine N_1 speed and exhaust temperature will be added to the digital data list. Shaft speed A-1 is deleted.

Redlines will be as noted. If any bearing temperature rises above 250F or if bearing failure appears to have occurred, emergency braking will be used to bring speed down below 500 rpm as quickly as possible.

Note that the number of lubrication flowmeters is reduced to the original four.

4.2.5 Safety

In addition to the precautions used previously, it will be necessary to assure against noise exposure of test personnel. Also, safe fuel handling procedures will be required.

4.2.6 Test Procedure

The test engineer will be responsible for a step-by-step procedure which will accomplish the following:

a. Check out facility oil, air, and fuel supplies. Check out control panels for power and operation. Facility vacuum will not be used. The brakes will be used only in an emergency, as specified in the redline values, but air must be available.

b. Turn on module and facility lubrication systems with enough oil supply to last one hour, in the absence of leakage through the module seals. Start instruments.

c. Pressurize the fuel tank, open the engine fuel valve then start the Lycoming engine. The Army representative will supply any procedural instructions for the jet engine. The jet will be limited to its minimum idle speed for the first run. If it will not start, cut off facility systems and follow instructions of the Army representative.

If it does start, monitor the flywheel speed closely. When it reaches 3000 rpm or at any redline, turn off the jet. If it does not reach 3000 rpm in ten (10) minutes, turn off the jet. In an emergency, the brakes can be turned on to bring speed below 500 rpm. When the flywheels are stopped, the lube systems can be refilled and the spillage drained from wherever it has collected.

Reduce data to obtaine a figure for steady acceleration of the flywheel at engine idle or maximum flywheel speed at idle, whichever applies.

Note: Do not over brake. There is no indication of reverse motion.

d. When the length of idle time needed to reach 3000 rpm or the steady speed reached in ten (10) minutes is established, a second and third start can be attempted using above idle power from the jet for short periods but keeping the flywheel below 3000 rpm. The engine is to be shut down before ten (10) minutes run and the flywheels will be allowed to drift to a stop. When they are below 500 rpm, the air and module vacuum systems can be drained of oil and the lubrication reservoirs topped off.

e. When the jet engine can be operated properly and the procedures are well understood, the facility will be shut down and the brakes removed. The brakes will be sent to Rocketdyne for addition of seals, to protect against excessive leakage into the facility vacuum system.

f. Data obtained shall be reduced and studied to determine any changes needed for future testing. It is anticipated that Test C of RC1290A will be performed as soon as the brakes are repaired.

4.3 TEST REQUEST RS-31 FLYWHEEL TESTS C, D, & E

4.3.1 Introduction

During the last three weeks, the RS-31 flywheel test setup, particularly the brakes and lubrication system have been reworked to reduce leakage and improve lubrication pressure. It is expected that tests C, D, and E can be run in quick succession without the need for corrective rework.

These tests will be nearly the same as the original callouts in Specification RC1290, with minor changes to reduce costs and take advantage of some objectives which have already been met.

4.3.2 Test Objectives

Test C will be a trial of the revised lube and brake systems as well as a search for the first critical shaft speed. The gas turbine will be used for a drive but will not be brought above idle speed so that acceleration and deceleration will be slow. The speed will be varied slowly from 0 to 6000 rpm with the brakes used from 6000 rpm at least once. The running test will be preceded by a lube system checkout with the module inoperative. Brake vacuum will be used and complete instrumentation.

Test D will follow as soon as data reduction is complete on Test C, including data playback of the analog tape signal to assure proper identification of any critical speeds.

Test D will run to 6000 rpm, dwell at this speed long enough to stabilize temperatures, then accelerate to 11,000 rpm in 1000 rpm steps, dwelling at each level long enough to read all instruments and to try to anticipate any problem areas. The flywheel will then be stopped by the brakes.

Test E can be run as soon as the data reduction for Test D is complete unless some problem makes it necessary to rework or repair some element. If repair is necessary, Test E will begin with a checkout of the repair. The jet will then be operated at 700 lb ft torque long enough to bring the flywheel to 11,000 rpm, then a slowdown, a reclutching and hold at 11,000 rpm, for five minutes will be performed. The brakes will be used to stop. If this is successful, Test F will follow as the concluding test in this series. Another test request will be written for this test.

4.3.3 Hardware to Be Tested

a. LE76-030-ER Flywheel Assembly
   This will have scavenge air bleeds added to the forward bearings but with the LH bleed plugged. The baffle will be used in the RH front bearing.

b. LE76-224-ER Brake Assembly
   LE76-225-ER Brake Assembly
   Both brakes will have bearing seals added by Rocketdyne.

c. LE76-031-ER System Test Interconnect
   Voltmeters and limit alarm modules will be checked and repaired as necessary.

d. LE76-071-ER RS-31 Mechanical Diagrams
   Piping will be per attached schematic, Fig. , or Change E of the blueprint. This includes the 30-gallon added oil reservoir.

4.3.4 Facility

The Hydro-Mechanical Laboratory test cell outside Building 252, as described before, will be used. Facility lubrication piping is included in the attached schematic diagram.

Instrumentation will be per the attached list. This list has been changed as noted below.

a. Oil pressures will be set to the original requirements of LE76-071-ER. The gearbox oil pressure switch is to be set at about 6 psi and the warning light panel will be operative.

b. The gap sensors (except M27) are required. One left gap and one right gap will be monitored for redline.

c. Three new digital channels are required, M51, M53, and M55.

d. Gearbox oil flow should be prepared to read 9 gpm and should come on scale at 4000 flywheel rpm.

e. The filtered vibration readings (A3, A4, A5 and A6) will re rescaled to 5 g full scale and redlined at 2 g. This should help find the shaft critical. The development engineer will help monitor vibration for Test C.

f. The RH speed (MI) will be recorded on the analog tape.

Redlines are listed. If any redline is exceeded, the test will bue "cut and braked" as quickly as possible.

All tests will be performed according to the detail test procedure written by Test and approved by the development engineer.

4.3.5 Test Procedure

4.3.5.1 Lubrication System Checkouts

a. Run the pumps and adjust pressures as follows:

P_1 - Fwd Oil Pressure - 175 psig
P_3 - Aft Oil Pressure - 500 psig
M_{57} - Brake Oil Pressure - 60 psig
- Facil 23 gpm pump - 450 psig

b. Turn on oil heater, leaving pumps running and raise oil temperature at M10 to 140-150F. Adjust thermostat to hold the temperature at 150F. Keep running at 150F for 30 minutes.

c. Take an oil sample and inspect for air bubbles. If no air is found, proceed. If air is still mixed with oil, stop running to determine and cure the problem.

d. When air free oil is assured, increase the pressures of Para. (a) if needed to obtain a minimum reading of 2 gpm on M49 flowmeter and 25 gpm on M59 flowmeter. M57 must be at least 20 psi below P_1.

e. Measure the oil flow coming out of the facility scavenge pump on the left front bearing by diverting it into a beaker for known time.

f. Admit facility vacuum to the brakes, using valves V6 and V8 to control the brake pressure.

g. Adjust P_1 to 7.5, 6.5, 5.5, 4.5, 3.5, 2.5 and 1.5 psi and measure the scavent flow at each pressure. Make a final adjustment of V6 and V8 to hold the vacuum at the lowest pressure where the scavenge flow is equal to that measure in Para. (e).

4.3.5.2 Perform Test C

a. Perform a system check and insure that the oil is warmed to between 140 and 150F. Obtain facility vacuum and brake air pressure. Apply vacuum to brakes. All accelerometers and the vibration recording system must be operating. The development engineer and the dynamics engineer will monitor the vibration level throughout the test.

b. Start the jet engine and set it for a low idle speed. Allow the flywheel to accelerate slowly to 6000 rpm. The jet engine speed may be increased if necessary to reach 6000 rpm. Flywheel redline speed is 6500 rpm of of the left flywheel.

c. Stop the jet and allow the flywheel speed to decay to 3000 rpm.

d. Restart the jet and gently accelerate to 6000 rpm again.

e. Apply brake air pressure to bring the flywheels close to a stop. Reduce data as applicable.

4.3.5.3 Perform Test D

a. Setup is the same as Test C.

b. Accelerate the jet and the flywheels to bring the flywheels to 6000 rpm. Reduce the jet power to idle and allow the flywheels to accelerate slowly to a stable speed or five minutes, but keep below 11,000 rpm by turning the jet off if necessary. Redline speed will be 11,500 rpm.

c. If necessary, accelerate the flywheels by applying jet power to hold steady at 7000, 8000, 9000, 10,000 and 11,000 rpm as may be available. Hold 30 seconds at each of the above speeds as possible.

d. After holding steady at 11,000 rpm for two minutes, turn off the jet and allow the flywheel speeds to decay below 6000 rpm.

e. Apply the brake air to stop the flywheels.

f. If no evidence of problems appears, Test E may follow immediately. If problems occur, data reduction and problem solutions will be required.

4.3.5.4 Perform Test E

a. Setup is the same as for Test C, but an EWR may be written to require checkout of any hardware changes.

b. Start the jet and accelerate at 500 to 700 lb ft torque to the highest safe speed as determined in Test D. Reduce the jet to idle.

c. Hold the jet at idle or a little above to complete a gentle acceleration to 11,000 rpm. Redline speed will be 11,500 rpm.

d. Reduce the jet idle, wait for the flywheel speeds to reduce below 10,000 rpm, then accelerate the jet to bring the flywheel up to 11,000 rpm again.

e. Stop the jet and when it is stopped, apply the brake air to stop the flywheel.

f. Reduce data. If the data reduction does not indicate any problem, Test F can be run. A new test request will be written for Test F.

4.4 TEST REQUEST RS-31 FLYWHEEL TEST F

4.4.1 Introduction

Test F is intended to show that the RS-31 Flywheel is ready for initial operation at 30 KW rating and can withstand overspeed to 32.5 KW. Due to the checkouts and previous tests, the mechanical systems are expected to cause no problems and all necessary instrumentation will be operative.

Hardware and facilities will be the same as Tests D and E (RMME 9172-5473, 18 October 1979) including the instrument list. Two TV cameras will be aimed through the gap windows and displayed in the console area as backup for the electronic gap sensors. These will be redlined at .010 gap. One will be recorded on tape along with a verbal record of speed during the first part of this run. Color moving pictures will be taken showing the setup and inspection portions of the run.

4.4.2 Test Procedure

a. Perform system checkout, obtain facility air and vacuum. Start lube system and instruments. Arm redlines. The following test schedule is shown graphically on the attached figure.

b. Start jet engine, accelerate flywheel to 11,000 ±200 rpm, reduce jet speed to 8000 rpm idle, allowing flywheel to drift while all instruments are checked for satisfactory readings.

c. Accelerate to 12,000 rpm and check instruments as above.

d. Accelerate to 13,000 rpm and check instruments as above.

e. Accelerate to 14,000 rpm and check instruments as above.

f. Accelerate to 14,500 rpm ±100 rpm. Reduce jet to idle. Monitor instrument while flywheels drift down to 11,000 rpm of the faster wheel.

g. Re-accelerate to 14,000 rpm $^{+100}_{-200}$ rpm. Start acceleration slowly, then apply about 1000 lb ft torque. Start cutting the jet at 13,700 to 13,800 rpm and reduce it to idle. Check all instruments.

h. Reclutch at high speed and accelerate carefully through 14,500 up to 15,100 ±100. Reduce jet to idle and allow flywheels to decelerate until the faster wheel is at 14,500 then gently accelerate jet, bring both flywheels to 14,500 rpm ±100 rpm, and hold nearly steady for at least five minutes.

i. Cut the jet engine then brake the flywheels to a stop.

j. Shut down and inspect hardware and data.

k. If no discrepancies are found, restart the jet, accelerate at 750 to 1000 ft lb torque to 14,500 ± 200 rpm, stabilize at 14,500 rpm by throttling the jet, hold speed for 5 minutes and cut the jet. Allow flywheels to drift down to 0 rpm.

5.0 RESULTS OF TEST

5.1 Test Chronology

Fifteen flywheel system tests were conducted during the period of 10 September through 29 November 1979. The following table provides a brief summary of the tests:

TEST NO.	DATE	SPEED	COMMENTS
A-1	10 Sep 79	450 rpm	Limited due to seal leakage of oil into the flywheel chamber and air turbine exhaust ducts. Flywheel was driven by the facility air turbines.
A-2	11 Sep 79	550 rpm	
A-3	19 Sep 79	1265 rpm	

Flywheel rotor seals were re-seated using an external pressurizing technique to reduce leakage.

B-1	27 Sep 79	-	• AVCO engine stalled at start
B-2	27 Sep 79	3000 rpm	Successful tests to target speed using AVCO engine served to verify basic F/W rotational integrity.
B-3	27 Sep 79	3500 rpm	

Facility brake seals were replaced. Lube oil system scavenging and sump capacity were increased.

C-1	9 Nov 79	1742 rpm	• Aborted due to erratic sensor.
C-2	13 Nov 79	4593 rpm	Successful tests to target speed verified excellent rotor dynamics and absence of first critical speed resonance.
C-3	13 Nov 79	6606 rpm	

Critical data review verified that testing could proceed through first critical (4000-5000 rpm) without concern for vibration or damage.

TEST NO.	DATE	SPEED	COMMENTS
D-1	14 Nov 79	11,387 rpm	• Successful test beyond planned Phase D speed target.

Data review conducted to evaluate vibratory resonance noted after start of coastdown. Resonance was correlated to facility brake bearings and determined to be within acceptable limits.

E-1	16 Nov 79	2,278 rpm	• Aborted due to unseated F/W rotor seals; reseating required.
E-2	19 Nov 79	11,000 rpm	• Cut for oil pressure decay requiring subsequent use of coolers.
E-3	19 Nov 79	13,400	• Cut for limited AVCO engine speed setting requiring reset.

External pressure seal reseat was required after test E-1 because of inadvertant brake evacuation timing error just prior to test E-1 which caused the seals to be unseated just prior to test. Lubrication system flow control valve settings were adjusted after Test E-2 so as to initiate flow through the oil cooler before increased oil temperature reduced oil viscosity excessively allowing pressure to decay. Since test E-3 had proceeded to a record speed level of 13,400 rpm when it was noted that the AVCO N_2 speed limit had been reached, it was decided to cut off and verify the reset procedure before performing a new step in system control.

F-1	26 Nov 79	14,500 rpm	• Successful duration test at rated speed.
F-2	29 Nov 79	14,850 rpm	• Successful excursion test to limit speed.

5.2 Test Descriptions

Test A-1 was the initial trial for accomplishment of Test A objectives. The specified test procedure was followed through Step 2.2 although the speed achieved (450 rpm) was 10% below the target of 500 rpm due to brake air control sensitivity at very low speeds. A decision was made not to proceed beyond Step 2.2 (to higher speeds) because it was noted that oil was leaking into the rotor chamber (by TV monitor through chamber windows) and that facility oil supply was decaying rapidly (due to brake seal leakage into the exhaust air). Application of facility vacuum was not adequate to resolve the chamber oil buildup problem and reseating of the seals did not succeed.

Test A-2 was a repeat of the previous test with no significant revision to the conditions, however, additional facility oil scavenge capacity was added to extend possible test duration. The oil leakage rate once again dictated test cutoff at the first speed plateau (550 rpm) after Step 2.2 of the procedure. Post-test review of data indicated, however, that chamber pressure had started down after facility vacuum and seating pressure substeps were completed.

Test A-3 was a third attempt to get the system seals seated and proceed to higher speeds and this time the test was able to proceed through Step 2.3 and initiate Step 2.4 leading toward the 1500 rpm plateau when it became necessary to shut down due to oil supply exhaustion due to both brake and module rotor seal leak rates. Module sealing was judged to be improved, but still unsatisfactory and brake seal oil leakage was very severe.

Summary - Test A. Although the objectives of Test A were not fulfilled by the first three trials, it was judged to be advisable to proceed to Test B for the following reasons:

1. Since air flow through the brakes tended to discharge oil that could otherwise be scavenged and recirculated, test duration and opportunity to resolve module module problems would be enhanced by reserving brake operation only as an emergency cutoff measure -- per their primary design objective.

2. A revised static procedure was conceived and successfully used to reseat the module rotor seals, thus operation of the system to higher speeds was judged to be constrained solely by brake seal problems.

Test B-1 was the first trial run of the system in the normal jet engine driven mode, however, the jet could not be brought on at idle without stalling therefore this first attempt was aborted.

Test B-2 was successful in achieving full target speed of 3000 rpm and thereafter the system was allowed to coast down to a stop as planned.

Test B-3 was added to repeat the results of Test B-2 primarily for increased confidence and operating experience and secondarily to checkout the ability of the brakes for emergency cutoff before higher speed operation was attempted. Test B-3 met these objectives and justified proceeding to turn attention to resolution of the brake seal leak problem.

Summary - Test B. Test series B served to verify that driver engine/flywheel module test progress was basically limited by facility brake seal leakage problems; therefore, an overhaul of brake seals was scheduled before proceeding to higher speeds. It was noted, however, that several concurrent improvements in the deliverable lube oil system would enhance performance and confidence in system operation at the higher speeds and longer durations planned. Reservoir capacity was increased fourfold, adjustments were made to reduce aeration, and scavenge lines were optimized while brake seal replacement was underway.

Test C-1 was initiated but cutoff within 76 seconds of startup because the RH rotor speed signal circuit was not responding. When engine speed reached 10,467 rpm, the RH rotor signal was -145 rpm. The problem was traced to poor grounding connections and corrected before Test C-2.

Test C-2 was carried to a rotor speed of 4478 rpm using the driver engine (which was accelerated to 10,260 rpm) after which the air brakes were actuated to augment deceleration. This was the first test into the speed range where the rotor first critical speed was predicted, therefore dwell at peak speed was not desired pending test data analysis. Review of data gave no indication of resonant or any other significant vibration.

Test C-3 was also conducted on 13 November and rotor speed was driven to 6606 rpm, followed by braking to 2142 rpm, immediate reacceleration to 6100 rpm, and finally, brakes were again used to return to stop. Once again, the data review verified that rotor dynamic performance was excellent with no reason for concern about operating in or near the first critical speed regime.

Summary - Test C. Test series C was judged to have cleared away any concerns about operation of the flywheel up to 6600 rpm and provided adequate data to project that testing could be safely advanced to the design range of 10,000 to 15,000 rpm. The brake seal modifications were found to have eliminated concern about loss of facility oil as to provide confidence in the availability of braking power at higher speeds and after longer duration runs. Also, many of the prior concerns about module bearing flows, temperatures, and pressures were resolved by the success of series C.

Test D-1 was conducted one day later, on 14 November 1978, with flywheel rotor speed brought smoothly to 8918 rpm. At this point, the engine was cutoff allowing rotor speed to decay to 7825 rpm and restarted to evaluate reclutching of the drive system. Reclutching was accomplished and speed was then brought to 11,387 rpm then cutoff allowing the flywheel to coast down for 200 seconds before the brakes were used. Speed decay during coast down averaged about 6.88 rpm/sec followed by decay during braking at an average rate of 48.8 rpm/sec with the initial braking rate much faster due to greater brake torque at the higher speeds. This was the first test brought to speeds high enough to obtain relatively good gap sensor data and the results were judged to follow predicted values for wheel growth versus speed.

This test, D-1, was considered to have properly resolved all of the objectives of the plan allowing test activity to proceed to Test E.

Test E-1 was conducted two days later on 16 November 1979, however, during the pretest procedure, the brake housing facility vacuum was turned on too soon causing the forward flywheel housing seals to become unseated so that bearing oil was noted at the housing windows during startup of the test. Data also showed that the rotor chamber evacuation was poor (at 2 psia rather than 0.2 psia as required). For this reason, Test E-1 was terminated at 2353 rpm and action was taken to reseat the forward rotor bearing seals by application of positive pressure in the bearing chamber.

Test E-2 was initiated on 19 November 1978 after rotor chamber evacuation capability had been verified. Rotor speed was advanced to 7937 rpm, however, the first attempt to stabilize at 8000 rpm was thwarted by drive engine stall. A second engine start 90 seconds later also stalled, however, the third start 240 seconds later was successfully held. By this time, rotor drive speed had decayed to a minimum of 5800 rpm (at 6.28 rpm/second) and was then raised to speed plateaus of 8000 rpm, and 8900 rpm for about 1 minute each and then advanced to peaks of 10,925 rpm and 11,437 rpm. Within about 20 seconds thereafter, brake power was used to decelerate rotor speed to a stop. The cutoff at 11,437 rpm was earlier than planned because of decay in forward bearing oil pressure (below the 75 psi redline) but evaluation of data established that the lower pressure was merely a consequence of the reduced viscosity of the heated oil and actual flow of lubricant was stable.

Test E-3 was also performed on 19 November 1979 shortly after review of E-2 data and consisted of a ramp directly to 10,800 rpm with a hold for about 50 seconds to check data followed by speed advance to 13,375 rpm. Rotor speed was held in the region of 13,400 for about 200 seconds and then brakes were applied for 60 seconds to decelerate from 12,062 rpm to 10,462 rpm (at 27 rpm/sec) with hold at 10,500 rpm for another 200 seconds. Finally, time braking power was applied to decelerate to a stop in about 150 seconds.

Summary - Test E. The three tests of series E provided the required base of high speed data and system operating experience required to proceed to full and limit speed operation. In particular, test series E permitted the oprator to obtain a better feel for how flywheel rotor speed responded to engine drive torque at the minimum and maximum torque levels. In addition all data was carefully evaluated over a five day period to ascertain the degree to which results correlated to predicted performance with particular emphasis on rotor growth versus speed, vibration levels, and lubrication. With the exception of low speed operation, where oil mist in the rotor chamber has a relatively strong influence on capacitance, rotor gap measurement was of significant value in evaluating rotor growth and in verification that the growth continued to be elastic at the peak speeds of Test E-2 and E-3. Vibration levels continued to be extremely low and non-resonant in nature confirming the good balance and dynamic damping of the rotor/bearing system. All bearing flows and temperatures were found to be satisfactory with no evidence of harmful conditions at any speed or mode of operation. In preparation for the final series of tests (F), the primary limitation considered necessary was to limit overspeed to 14,850 rpm (about 2.4%) to avoid any possiblity of rotor contact with the barrier ring. It had been predicted that rotor overspeed could be allowed as high as 16,500 ±800 rpm before point contact of the rotor edge (to ring alarm spots) to assure that braking would occur if speed exceeded the 17,600 rpm yield level. It was determined that larger than desired assembly process tolerances could allow brake ring contact as low as 14,900 rpm (as a minimum) and that even though contact-braking was a design safeguard against failure, it was not desirable to instigate contact by intent.

Test F-1 was performed on 26 November 1979 demonstrating more than 1400 seconds of flywheel operation at speeds to 14,500 rpm. The flywheel system was initially powered to 13,337 rpm and held in the region between 13,000 rpm and 13,500 rpm for 2 minutes before proceeding to a momentary excursion peak of 14,500 rpm. Then, the speed was allowed to decay to 10,850 rpm over a 380 second period (average decay rate of 9.6 rpm/sec). At 10,850 rpm, the drive engine

speed was increased to reclutch the flywheels and rotor speed was once again advanced to 14,500 rpm. An excellent degree of operational control was then demonstrated for a period of 5 minutes during which speed was held between 14,400 rpm (min) and 14,500 rpm (max). After completing the 5 minute dwell, the air brakes were applied to bring ther rotor to a halt in about 200 seconds. Test F-1 proceeded exactly as desired with no deviations or problems noted.

Following Test F-1, gap sensor data were carefully reviewed serving to verify that rotor strain was continuing to display elastic properties at the rated 30 KWH design speed of 14,500 rpm.

Test F-2 was conducted three days later, on 29 November 1979. Test F-2 consisted of a single high torque acceleraction of the rotor to 14,850 rpm in 260 seconds (57 rpm/sec) followed by unbraked rotor speed decay to below 300 rpm over a 2100 second period. At the peak, rotor speed was held above the 14,500 rpm rated point for 110 seconds. Once again, flywheel performance was excellent. This test concluded the R&D demonstration of RS-31 system performance prior to delivery to MERADCOM for in-service operation.

6.0 TEST DATA

6.1 Types of Data Systems

RS-31 flywheel system test data was monitored and/or recorded using four principal data stations as follows:

a) Visual gages in the cell for pre-test adjustments and checkouts
b) Visual gage alarm lights and meters at the operator's panel for on-duty monitor of performance.
c) Oscillographic and multipoint printer recorders for both monitor and permanent record at a nearby data station in the control area.
d) Tape recorded data suitable for post-test playback and signal conversion into analog and digital records.

Tables 8.2 and 8.3 of Test Specification RC-1290 (as presented in Final Report RI/RD78-207) lists the nominal data channels which were utilized. Figures 7.6.1 and 7.6.2 of that report portray the control console layout of the visual displays.

6.2 Typical Data Result

Out of consideration for the voluminous data accumulation over the span of the 15 test series, Tests C-2 and F-1 have been selected for representative data presentation herein. Thirty-five channels of printed data are given in Appendix A over a 1630 second duration at 10 second data intervals.

In addition, computer graphic plots of recorded data are given in Appendix B for nine specific tests. Data has not been included for six tests:

A-1 No significant results (~3% of rated speed).
A-2 No significant results (~3% of rated speed).
B-1 Engine stalled at start.
C-1 Aborted due to erratic sensor.
C-2 No plots made. See Appendix A.
E-1 Aborted due to rotor seal leakage.

6.3 Discussion of Test Data

Test A-3 was the first wherein speed was raised above 3.5% of the rated value. The data plots for this air brake driven flywheel test show the acceleration in speed to have three periods with two plateaus in between. Note that aft oil pressure was lost moments before the peak speed was reached as oil leakage caused depletion of the oil reservoir.

Test B-2 data plots for this engine driven flywheel test show rotor speed rising to about 3000 rpm as a consequence of engine acceleration to the range of 8,000 to 10,000 rpm. Other plots show bearing temperatures (one erratic due to loose connections), cavity pressures (the right side sealing intermittantly at start), and accelerometer data (no significant 0-3000 rpm resonance; which would be at 0-50 Hz).

Test B-3 data plots show speed increase to 3,000 rpm, expanded scale data for bearing temperatures (with repaired RR bearing sensor), and similar cavity pressure and vibrational plot results to B-3.

Test C-3 data plots display speed advancement to 6,000 rpm in two ramps demonstrating low speed reclutching at 2,142 rpm (550 seconds time). Gearbox oil flow rate is shown proportional to rotor speed. The high value of aft oil flow (8 GPM) is atrributed to minimal centrifugal resistance of the central shaft port at low speeds (0-6,000 rpm). Brake and forward oil flows are steady at 1.3 GPM. Plots of oil pressures show the slight effect on aft pressures as increased shaft speed increases path resistance and on forward pressure as low rotor speed increases path resistance. Oil temperature plots show the effects of rotor bearing heat dissipated in the oil as a function of speed. No cooling loop flow was programmed at these low speeds, however, reservoir and line oil temperature data (m10, M70, and M71) show that natural conduction of heat served to keep the system oil temperatures stable.

Test D-1 plots show speed driven to 9,000 rpm and later, after reclutch demonstration at 8,000 rpm, is brought to 11,000 rpm. over the longest duration

operation to that point in time. Oil system data plots display a line relief valve problem influencing M23 aft oil pressure and M50 aft oil flow. At the higher speeds of Test D-1, rear bearing-exit oil temperatures are shown to approach 200 F while forward temperatures approach 165 F - as desired for proper viscosity, thus oil inlet temperature begins to reach 150 F (the target value) for the first time in test progress to date. Note cavity temperatures are still quite low at speeds below 12,000 rpm as windage losses are small and easily disipated.

Test E-2 data plots show speed again brought above 11,000 rpm with an interim 6,000 rpm reclutch demonstration. Brake oil flow (M59) was seen to be erratic at 900 seconds due to sensor problems. Although aft oil flow relief valve chatter influenced pressure at 600 to 1,000 seconds, there was no significant effect on aft oil flow. Plots of gap space (actually rotor growth) versus time are shown to follow rotor speed and growth versus speed plots show accurate representation of the predicted stress/strain curve for the rotor material above about 8,000 rpm where oil moisture influences are overcome and signal strength is improved.

Test E-3 data plots show speed advancement to 13,400 rpm. Rear bearing oil exit temperature rose to about 220 F at peak rotor speed but the aft oil inlet temperature did not exceed the design point of 150 F. The gap data of Test E-3 was degraded by a surplus of oil in the rotor chamber at start from the preceding E-2 test run shortly before (without time taken for thorough evacuation between tests). At about 5 minutes into the test at 11,000 rpm, the oil began to be disipated and gap data error was eliminated in the righthand chamber but the left side residual oil took longer to vaporize off.

Test F-1 data plots display speed brought to 14,500 rpm twice. Note that the oil cooler served to take over control of oil supply cooling (M10) at 150 F even though the rotor was held at 14,500 rpm for extended duration. Aft oil pressure (M23) decaved as lower speed decreased centrifugal resistance and oil viscosity dropped with higher temperature. During the 5 minutes, 14,500 rpm plateau conditions were stabilized. Test F-1 was a good test of

the gap sensor system, especially in the relatively dry righthand chamber, but a slight shift in the left chamber was noted during the speed decay excursion due to a low level continuing oil seal leak.

Test F-2 data plots show speed accelerated rapidly to 14,850 rpm followed by long term unbraked deceleration. This deceleration was enhanced by brake drag as brake vacuum was held relatively moderate (at 2-4 psia) to avoid impact on the flywheel shaft seal pressure balance. Note that aft oil pressure (M23) peaked to its maximum value at high rotor rpm so that aft oil flow (M50) was held above 7 GPM for safe lubrication of both the bearings and the clutch hardware. The gap data was slightly erratic during the rapid start but excellent at high speed with further perturbation due to oil leakage in the tail of the long duration coastdown.

7.0 TEST PROBLEMS AND SOLUTIONS

Only a few relatively minor problems were encountered during the program of RS-31 flywheel test. Of these, a facility auxiliary subsystem (the gas turbine braking device) was the most significant problem. Shaft oil seal leakage, internal to the brake rotor, constrained test duration and speed as a consequence of severe depletion of oil by loss to the exhaust duct. Since this problem was solved by seal replacement, testing of the RS-31 was then successfully concluded; no further discussion of this non-deliverable hardware problem has been presented.

7.1 Rotor Shaft Seals

Each flywheel rotor assembly is operated in an evacuated chamber to minimize aerodynamic drag so that speed decay is resisted and so that rotor heating is limited. A set of rotor shaft seals are used at each end of each rotor (total of 4 seals) to restrict flow of air and bearing lube oil into the evacuated rotor chamber. The seals were installed in place during module assembly in March, 1978, and at that time, a test was made which proved the

ability of the seals to hold a vacuum for an extended period of time. Subsequently, 18 months later, when system testing was initiated, the first attempt to pull a vacuum on the low pressure side of the seals resulted in excessive leakage. Flooding the bearing cavity with oil to lubricate the seals and alternately pressurizing each side of the seal did not correct the problem.

Inspection of two new seals out of stock revealed the following:

1) The carbon face is flat within 3 helium light bands.
2) The leakage on the vacuum plate was acceptable (.8 to 1.0 inch Hg pressure loss in 60 seconds).
3) Face load of complete seal assembly was 4.5 to 5.5 lbs until O-ring stopped rolling, then increased suddenly to 22 lbs.
4) Face load with springs removed was negligible with O-ring rolling and increased to 14 lbs with O-ring sliding at ID (lubricated).
5) Face load with O-ring removed, springs installed, was 4.5 to 5.0 lbs.
6) Dimensional measurements:

Face OD 4.248 ± .002 is 4.2459
Face ID 4.090 ± .002 is 4.0885
Skirt OD 4.010 ± .003 is 4.0083 - 4.0102
O-Ring Groove OD 4.290 ± .002 is 4.2883
(1) O-Ring ID ± .044 is 3.984
(1) O-Ring Section .144 ± .0045 is .145
O-Ring Groove Width .225 ± .005 is .2247

The inspection results indicate that the O-ring friction drag while sliding at the ID (14 lbs) exceeds the spring load (0.5 to 5.0 lbs); therefore, the seal will not function unless the O-ring is rolling.

Analysis indicated that the O-ring is apparently sticking at the ID to the composite skirt OD and sliding at the O-ring OD when vacuum is pulled on the

- - - - -

(1) Viton Nichols 8273 after swelling with MIL-L 23699, ID 2.859 ± .028 and section .139 before swelling

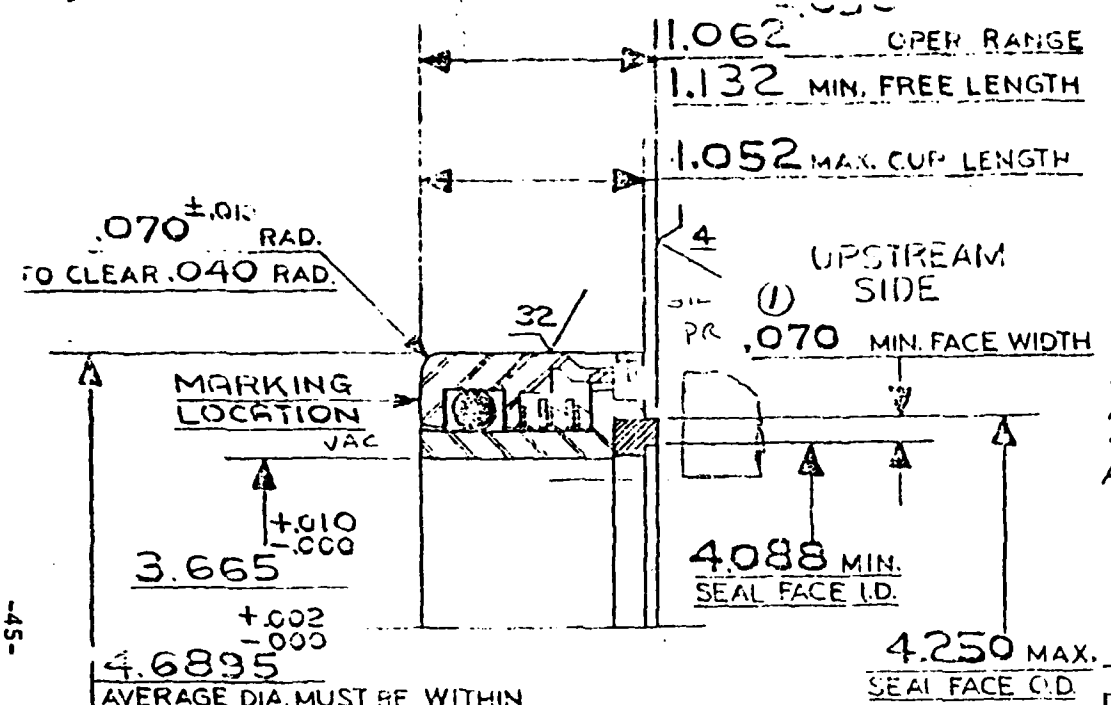
downstream side. The pressure differential acts on the larger effective area out to the O-ring OD. The piston effect, created by the O-ring and composite (adapter assembly), results in a pressure induced force which exceeds the spring load and unseats the seal face causing leakage. The opening force is equal to the 5 pound spring load at 5.87 psid. The test results indicated that the seal started to leak in the flywheel assembly at approimately 5 psid.

The analysis indicated that the seals could be seated by increasing the pressure differential to approximately 20 psid. The higher pressure will push the O-ring against the bottom of the O-ring groove eliminating the piston effect of the O-ring. The pressure then acts on the area between the skirt OD and face OD resulting in a closing force equal to 20.5 lbs at 20 psid. The seals were successfully seated in the flywheel assembly using this method.

The flywheel test program was completed after the seals were seated; however, leakage into the vacuum cavity after seating was estimated to be in excess of the design goal of 5 SCIM.

The seal supplier recommends changing the O-ring groove OD from 4.290 to 4.276 inches to increase the O-ring squeeze. The present squeeze has a tolerance range of .011 to -.033 inch. The revised squeeze would be .004 to .018 inch. The new seal from stock measured .005 to .006 inch squeeze, which is within the recommended range; therefore, the revised squeeze may not correct the problem.

A revised seal design solution has been considered to eliminate O-ring rolling for more positive location of the pressure balance diameter. The O-ring diameter would be controlled to reduce the stretch for minimum drag load. A low friction plating on the skirt diameter would be used to reduce drag friction. The skirt diameter and/or carbon nose diameters would require revision for proper pressure balance. The spring load would be increased to compensate for the O-ring drag and inertia loads at high speed. Two spare seals from stock (S/ 002 and 006) have been returned to the seal supplier for failure analysis and rework at his expense.



AVERAGE DIA. MUST BE WITHIN LIMITS SHOWN .005 OUT-OF-ROUND IN EXCESS OF THESE TOLERANCES PERMISSIBLE

SPRING LOADS
6.2 LBS MAX. AT 1.012 LENGTH
3.7 LBS MIN. AT 1.112 LENGTH

FACE AREA 1.05

A	59588	REV.

PART NAME	REQ.	PART NO.
CUP	1	60091
S.R.COMP	1	61334
SPRING	3	61348
O-RING	1	60093
RETAINER	1	60094
WASHER	2	61349

MARK BY ELECTRO ETCH
77843/459500 SER NO ---
RES1284-01(1)

NOTE:
1. THE STATIC AIR LEAKAGE SHALL NOT EXCEED 5 SCIM WITH 15±1 PSIG APPLIED TO UPSTREAM SIDE AT 1.062±.005 LG

4	WAS .085 MIN.	10984	10-7-77	ZB	
3	S.R. COMP WAS 5-33632-1-SSC2 REVISED SEAL FACE	ECN 10956	9-27 77	ZB	
2	SPRING 61348 WAS 60092 BODDED WASHER	ECN 10921	9-12 77	ZB	
1	[illegible]				
REV.	REVISIONS		CHANGE	BY	APP.

UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS & SHARP EDGES
RADII & FILLETS .010 .020
DIMENSIONS ARE IN INCHES
TOLERANCES IN
FRACTIONS ANGLES DECIMALS
.015 ±1.0° XX ± .010
XXX ± .005
FINISH ALL OVER
EXCEPT AS NOTED

DRAWN	CHKD	PROJ ENG	ENG
ZB			
7-26-77			

MATL & SPEC
BOX NO.
COLLAR NO
PROCESS SPEC

REFERENCES
COUTHERS 1284

SEAL ASSEMBLY

Figure 7

SCALE NONE WEIGHT

SEALOL INC.
PROVIDENCE, R.I.

FIRST USED ON S.O. 53704 NEXT ASSY 3-78

A 59588 REV. 4

-45-

7.2 Lubrication

MIL-L-23699B oil is used for lubrication of flywheel rotor shaft bearings, shaft seal rub ring contact surfaces, gearbox bearings, gear mesh surfaces, splines of shafts and over-running clutch bearings. Data from system tests has established that all system elements were adequately lubricated during operation so that no excessive wear or damage was likely. The principal problem of lubrication system operation during early tests was evidenced as poor scavenging of oil from discharges and excessive aeration of the recirculating oil so that test duration was limited by a tendency for the sump oil supply to decay in quality and quantity available for delivery to the pumps. During a down period for service to facility support equipment (during October, 1979, after Test B-3), sump capacity was increased, scavenge line arrangements were improved, and the de-aeration scavenge pump was throttled. These revisions sharply improved oil collection and reduced (but did not eliminate) oil aeration so that no further problems were encountered in extension of run time and operation to full speed.

7.3 Gap Sensor Channel M27

The left forward gap sensing circuit could not be made to function during the test program because of an electrically shorted condition between the barrier ring and the casing. Three possible explanations were postulated as follows:

1. One or more of the three left forward barrier ring installation port plugs were improperly installed during build using an excessively long plug (bolt) so that the plug touches the barrier ring.
2. The barrier ring itself is touching the case due to out of tolerance conditions or distortion.
3. Some unknown foreign object is wedged into a position so as to form a short between the ring and case.

Although postulate #1 would be easy to check and correct given access to the three plug locations, two of the three locations were inaccessible in the test installation. In the case of postulates numbers 2 and 3, corrective action is not possible without disassembly of the module. The first (plug) postulate can be checked out after the module is removed from the test cell and before installation at Ft. Belvoir, Virginia.

8.0 REFERENCE DATA

8.1 Drawings

LE76-030-ER	RS-31 Module
LE76-067-ER	RS-31 Instrumentation and Controls
LE76-071-ER	RS-31 Lubrication and Vacuum Subsystem
LE76-031-ER	RS-31 System

8.2 Documents

RI/RD78-207	RS-31 Final Report
RC-1290	RS-31 Test Specification

APPENDIX A

TYPICAL DATA RESULTS

DIGITAL DATA PRINTOUT FOR TESTS C-2 & F-1

Test C2

RS-31 FLYWHEEL TEST — ID:FW 1 — TAPE 357

DATA INTERVAL IS 10 SECONDS — 11/13/79 15:00:55 — FILE 06

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	N1	M51	M56
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	RECAV T	FLIG SPD	RB VAC	LB VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
0.0	0.00	0.00	0.00	0.00	14.7	14.7	71.0	0.6	14.53	14.79
10.0	0.82	8.16	0.01	0.00	12.5	12.4	71.0	-0.6	14.54	14.6[illegible]
20.0	0.14	8.31	0.00	0.00	8.8	8.8	71.1	0.6	14.41	14.5[illegible]
30.0	0.83	8.34	0.01	0.00	6.5	6.3	71.0	-0.6	14.44	14.56
40.0	1.17	8.32	1.30	0.00	4.6	4.6	71.1	-0.6	14.41	14.46
50.0	1.17	8.30	1.38	0.00	3.6	3.4	71.1	0.0	13.79	13.93
60.0	1.24	8.29	1.28	0.00	2.6	2.5	71.0	0.6	3.71	2.9[illegible]
70.0	1.29	8.28	1.29	0.00	1.9	1.9	70.9	-0.6	2.49	1.61
80.0	1.28	8.25	1.29	0.00	1.5	1.4	71.0	-0.6	2.80	2.02
90.0	1.28	8.24	1.31	0.00	1.2	1.1	70.9	0.6	2.87	2.17
100.0	1.28	8.22	1.34	0.00	1.0	0.9	70.9	-0.6	3.10	2.26
110.0	1.27	8.18	1.34	-0.00	0.7	0.7	70.9	0.0	3.26	2.53
120.0	1.26	8.13	1.34	-0.00	0.7	0.5	70.9	4815.0	3.33	2.63
130.0	1.26	8.09	1.33	0.00	0.7	0.5	70.9	10116.0	3.65	2.88
140.0	1.25	8.08	1.34	0.00	0.2	0.5	71.0	10197.0	3.67	2.86
150.0	1.24	8.06	1.34	0.00	0.8	0.4	71.1	10233.0	3.61	2.96
160.0	1.24	8.03	1.35	0.00	0.6	0.3	71.0	10251.0	3.69	3.09
170.0	1.23	7.95	1.34	0.00	-0.3	0.3	70.9	10269.0	3.87	3.20
180.0	1.23	7.85	1.34	0.19	0.2	0.4	70.9	10287.0	3.96	3.24
190.0	1.22	7.76	1.34	0.67	-0.1	0.4	71.1	10287.0	3.91	3.27
200.0	1.22	7.73	1.34	0.76	0.5	0.3	70.9	10287.0	3.94	3.24
210.0	1.22	7.60	1.34	0.86	-0.3	0.3	70.9	10314.0	4.05	3.3[illegible]
220.0	1.21	7.57	1.34	0.97	-0.0	0.4	71.0	10287.0	3.92	3.3[illegible]
230.0	1.21	7.50	1.34	0.96	0.2	0.4	71.1	10276.0	3.88	3.3[illegible]
240.0	1.20	7.43	1.34	1.02	0.3	0.3	71.1	10278.0	4.10	3.41
250.0	1.20	7.45	1.35	1.16	0.5	0.3	71.1	10278.0	4.09	3.5[illegible]
260.0	1.21	7.42	1.34	1.16	0.9	0.5	71.1	10269.0	4.05	3.49
270.0	1.22	7.38	1.34	1.32	0.6	0.4	71.1	10260.0	4.17	3.4[illegible]
280.0	1.21	7.37	1.35	1.44	0.7	0.3	71.1	10260.0	4.12	3.51
290.0	1.21	7.38	1.33	1.22	0.2	0.3	71.1	4815.0	3.97	3.47

RS-31 FLYWHEEL TEST

DATA INTERVAL IS 10 SECONDS

11/13/79 15:05:44

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	M1	M51	M54
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	RECAV T	ENG SPD	PB VAC	LB VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
300.0	1.21	7.47	1.34	0.01	0.3	0.4	71.2	1.7	4.07	3.48
310.0	1.23	7.56	1.33	0.00	0.3	0.2	71.1	0.6	4.14	3.43
320.0	1.23	7.60	1.34	0.00	0.4	0.3	71.1	0.6	4.13	3.48
330.0	1.23	7.64	1.33	0.00	0.2	0.2	71.3	1.1	4.01	3.50
340.0	1.23	7.58	1.34	0.00	0.7	0.3	71.3	0.0	4.11	3.55
350.0	1.24	7.66	1.33	0.00	0.6	0.4	71.3	1.1	3.98	3.49
360.0	1.25	7.67	1.34	0.00	0.2	0.3	71.2	0.0	4.15	3.48
370.0	1.25	7.63	1.33	0.00	0.6	0.4	71.3	0.6	4.05	3.54
380.0	1.25	7.69	1.33	0.00	-0.3	0.3	71.2	0.6	4.22	3.55
390.0	1.26	7.71	1.33	0.00	0.6	0.4	71.3	0.0	4.04	3.54
400.0	1.26	7.79	1.33	0.00	0.4	0.4	71.3	-0.6	4.18	3.51
410.0	1.27	7.78	1.33	0.00	0.3	0.4	71.3	1.1	4.07	3.53
420.0	1.27	7.77	1.33	0.00	0.5	0.3	71.3	1.1	4.10	3.52
430.0	1.28	7.82	1.33	0.00	0.4	0.3	71.3	1.1	4.09	3.53
440.0	1.29	7.80	1.32	0.00	0.3	0.3	71.3	-0.6	4.23	3.54
450.0	1.30	7.81	1.33	0.00	0.1	0.3	71.3	0.0	4.05	3.43
460.0	1.31	7.83	1.32	0.00	0.4	0.3	71.3	0.0	4.27	3.61
470.0	1.30	7.85	1.32	0.00	0.4	0.3	71.4	0.0	4.11	3.54
480.0	1.30	7.87	1.32	0.00	0.9	0.3	71.3	0.6	7.29	7.01
490.0	1.32	7.87	0.01	0.00	-0.0	0.2	71.3	0.6	7.52	7.21
500.0	1.32	7.85	0.00	0.00	0.3	0.3	71.4	-0.6	13.99	14.36
510.0	1.29	7.92	0.00	0.00	0.4	0.3	71.5	1.1	18.73	17.75
520.0	1.31	7.93	0.01	0.00	0.1	0.3	71.4	-0.6	18.98	16.19
530.0	1.30	7.90	0.00	0.00	0.4	0.3	71.5	0.6	18.91	15.51
540.0	1.32	7.98	0.01	0.00	0.3	0.3	71.4	-0.6	19.08	15.36
550.0	1.31	7.99	0.00	0.00	-0.0	0.4	71.5	0.6	19.00	15.09
560.0	1.35	7.89	1.28	0.00	0.3	0.3	71.4	-0.6	14.39	14.43
570.0	1.34	7.97	1.25	0.00	0.3	0.3	71.4	-0.6	14.48	14.44
580.0	1.35	7.90	1.26	0.00	0.3	0.3	71.4	-0.6	14.43	14.55
590.0	1.33	7.97	1.29	0.00	0.4	0.3	71.4	0.6	14.36	14.47

RS-31 FLYWHEEL TEST ID:FW 3 TAPE 367

DATA INTERVAL IS 10 SECONDS 11/13/79 15:10:44 FILE 06

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	M1	M51	M54
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	RECAV T	ENG SPD	RB VAC	LB VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
600.0	1.35	7.94	1.30	0.00	0.3	0.3	71.4	0.0	14.38	14.45
610.0	1.34	7.95	1.31	0.00	0.2	0.3	71.4	-0.6	14.46	14.45
620.0	1.35	7.93	1.31	0.00	0.4	0.3	71.4	0.0	14.28	14.33

RS-31 FLYWHEEL TEST ID:FW 1 TAPE 357

DATA INTERVAL IS 10 SECONDS 11/13/79 15:00:55 FILE 06

CHANNEL	12	13	14	17	18	19	20	10	50	51
	M22	M23	M24	M4	M5	M6	M7	M1	M2	M3
TIME	FOP	AOP	GBOP	RRBRT	LRBRT	RFBRT	LFBRT	RH SPEED	LH SPEED	SD SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
0.0	0.0	-2.0	0.6	72.9	70.9	74.2	74.6	-167.2	46.9	3.1
10.0	4.4	478.0	0.7	72.8	71.1	72.8	73.4	-168.8	8.7	75.0
20.0	39.5	478.5	0.7	76.1	73.6	72.5	73.1	-167.2	81.3	0.0
30.0	143.6	478.0	0.4	77.1	74.6	72.6	73.7	-167.2	34.4	50.0
40.0	186.6	472.0	0.7	77.8	75.0	73.8	75.1	-167.2	28.1	54.7
50.0	186.8	470.5	0.7	78.6	75.2	74.4	75.5	-165.6	40.4	19.3
60.0	186.5	467.5	0.4	78.8	75.5	74.8	75.2	-167.2	56.3	4.7
70.0	186.4	461.5	0.7	78.7	75.7	75.2	76.9	-165.6	59.4	32.8
80.0	186.3	461.0	0.8	79.1	75.9	75.4	77.3	-167.2	7.8	35.9
90.0	186.1	461.0	0.5	79.3	76.0	75.9	77.6	-167.2	75.0	0.0
100.0	185.5	457.5	0.7	79.4	76.1	76.2	77.6	-98.4	15.6	50.0
110.0	182.9	455.0	0.6	79.6	76.1	76.3	77.9	-203.1	26.6	103.1
120.0	180.4	454.0	0.4	79.4	76.1	76.2	77.6	-171.9	37.5	59.4
130.0	177.1	448.0	0.7	79.5	75.8	75.8	77.3	134.4	348.4	536.9
140.0	175.0	445.5	1.1	80.0	75.9	76.1	77.5	514.1	695.3	723.4
150.0	175.9	440.0	2.4	80.8	77.0	77.1	78.3	870.3	1078.1	981.3
160.0	174.3	427.5	3.6	82.2	78.1	77.6	79.3	1203.1	1414.1	1289.1
170.0	172.6	421.0	4.2	83.7	79.3	78.4	80.1	1520.3	1728.1	1637.5
180.0	171.1	416.0	5.5	85.0	80.1	79.5	81.2	1820.3	2012.5	1890.6
190.0	170.8	414.5	6.4	87.0	81.5	80.7	82.3	2109.4	2301.6	2212.5
200.0	168.5	401.5	6.8	87.0	83.3	81.9	83.0	2384.4	2585.9	2446.3
210.0	169.0	391.8	8.2	89.2	85.2	83.1	83.6	2656.3	2868.8	2675.0
220.0	168.3	397.3	8.3	90.9	89.1	84.3	84.5	2912.5	3128.1	2921.9
230.0	167.5	387.0	8.5	92.5	90.8	85.5	85.4	3162.5	3393.8	3140.6
240.0	166.1	393.5	8.8	93.6	92.2	86.6	86.3	3400.0	3568.8	3353.1
250.0	165.8	383.0	10.3	97.1	93.3	87.8	87.6	3620.6	3807.1	3606.3
260.0	164.4	389.8	8.9	99.1	94.8	88.8	88.3	3846.9	4021.9	3815.6
270.0	163.8	388.5	9.7	101.6	96.3	89.9	89.8	4056.3	4209.4	4025.0
280.0	163.0	385.5	11.4	102.5	98.6	90.9	91.1	4259.4	4459.4	4184.4
290.0	162.1	411.0	10.3	106.4	99.5	91.8	92.1	4403.1	4593.8	3640.6

RS-31 FLYWHEEL TEST — TAPE 357

DATA INTERVAL IS 10 SECONDS — 11/13/79 15:05:44 — FILE 06

CHANNEL	12	13	14	17	18	19	20	10	50	51
	M22	M23	M24	M4	M5	M6	M7	M1	M2	M3
TIME	FOP	AOP	GBOP	RRBRT	LRBRT	RFBRT	LFBRT	RH SPEED	LH SPEED	GB SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
300.0	162.5	414.0	4.4	107.5	100.3	92.4	92.8	4359.4	4543.8	1750.0
310.0	162.5	420.5	2.8	107.8	100.9	92.9	93.1	4478.1	4478.1	1240.6
320.0	162.6	424.5	2.6	109.0	102.4	93.2	93.4	4434.4	4481.3	1114.1
330.0	160.8	430.5	2.1	110.1	103.1	93.4	93.5	4387.5	4456.3	982.8
340.0	161.8	414.0	2.1	110.5	103.4	93.8	93.6	4343.8	4350.6	975.9
350.0	161.8	415.0	1.7	110.6	103.9	94.0	93.8	4296.9	4368.8	785.9
360.0	160.6	425.5	1.6	111.8	103.8	94.1	94.1	4250.0	4268.6	918.8
370.0	159.8	422.0	1.7	112.6	103.9	94.3	94.1	4206.3	4250.4	828.1
380.0	158.1	420.5	1.4	113.4	103.3	94.3	94.3	4162.5	4206.3	815.6
390.0	157.5	419.5	1.6	113.6	103.3	94.7	94.3	4115.6	4146.9	803.1
400.0	157.3	419.5	1.6	113.6	103.1	94.5	94.4	4062.5	4109.4	846.9
410.0	155.6	427.5	1.4	113.6	103.3	95.0	94.6	3893.8	4121.9	676.6
420.0	156.0	417.5	1.4	113.8	103.0	95.0	95.1	3850.0	4084.4	785.9
430.0	154.9	420.5	1.6	113.5	102.8	95.0	95.0	3803.1	4046.9	778.1
440.0	154.6	418.0	0.6	113.5	102.6	95.3	95.0	3762.5	3956.3	815.6
450.0	153.4	418.5	1.5	113.6	102.9	95.5	94.9	3718.8	3915.6	775.0
460.0	152.4	413.0	1.1	113.5	103.6	95.5	95.4	3681.3	3918.8	628.1
470.0	151.4	414.5	1.3	113.4	103.8	95.6	95.4	3646.9	3862.5	718.8
480.0	153.0	412.5	1.4	113.4	104.1	95.9	96.3	3731.3	3843.8	684.4
490.0	152.1	416.5	1.1	113.4	104.5	96.1	96.3	3681.3	3787.5	535.9
500.0	155.3	419.5	1.5	113.3	104.8	96.1	96.4	3634.4	3703.1	676.6
510.0	173.4	408.5	1.3	111.8	104.5	95.8	96.1	2934.4	3203.1	634.4
520.0	172.6	392.8	1.2	106.3	102.6	94.4	95.2	2328.1	2442.2	462.5
530.0	169.6	394.8	1.0	103.5	100.1	93.6	94.1	1670.3	1843.8	381.3
540.0	169.3	390.8	0.9	101.8	96.9	92.2	93.3	1042.2	1200.0	123.4
550.0	167.1	368.5	0.6	98.9	94.5	91.4	92.4	448.4	645.3	132.8
560.0	146.9	413.5	0.3	96.8	92.9	90.6	91.0	323.4	482.8	59.0
570.0	144.8	365.8	0.3	96.0	92.4	90.8	91.3	309.4	471.9	60.9
580.0	144.0	448.5	0.2	95.3	91.9	90.6	90.9	293.8	445.3	46.9
590.0	142.6	350.0	0.4	95.0	91.7	90.3	90.8	278.1	485.9	4.7

RS-31 FLYWHEEL TEST ID:FW 3 TAPE 357

DATA INTERVAL IS 10 SECONDS 11/13/79 15:10:44 FILE 06

CHANNEL	12	13	14	17	18	19	20	10	50	51
	M22	M23	M24	M4	M5	M6	M7	M1	M2	M3
TIME	FOP	AOP	GBOP	RRBRT	LRBRT	RFBRT	LFBRT	RH SPEED	LH SPEED	GB SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
600.0	143.6	422.0	0.5	94.5	91.4	90.3	90.7	264.1	432.8	66.4
610.0	142.9	430.5	0.3	94.6	91.3	90.2	90.3	251.6	409.4	67.2
620.0	143.3	356.0	0.7	94.6	91.3	90.1	90.3	239.1	423.4	67.5

RS-31 FLYWHEEL TEST RUN 1 TAPE 457

DATA INTERVAL IS 10 SECONDS 11/13/79 15:00:55 FILE 06

CHANNEL	52	53	54	55	56	57	58	59	62	15	10
	M9	M10	M26	M27	M28	M29	M31	M32	M56	M57	
TIME SEC	LFCAVT DEG F	AOT DEG F	RF GAP PICO F	LF GAP PICO F	RR GAP PICO F	LR GAP PICO F	LF VIB G	RR VIB G	RTAP PSIG	GTOP PSIG	TMT PULSE
0.0	72.6	80.0	-1.3	17.4	-5.5	-6.2	-0.0	-0.0	-0.37	0.20	-16.7
10.0	71.6	78.7	-1.4	17.4	-5.5	-6.2	0.0	-0.0	0.00	-0.64	-16.9
20.0	72.7	78.7	-1.4	17.4	-5.6	-6.2	0.0	-0.0	-0.86	0.20	-16.7
30.0	72.1	78.8	-1.4	17.4	-5.6	-6.3	-0.0	-0.1	-1.67	0.30	-16.7
40.0	71.3	78.8	-1.4	17.4	-5.6	-6.3	-0.0	-0.0	-0.81	10.13	-16.7
50.0	73.0	79.4	-1.3	17.4	-5.6	-6.3	0.0	0.0	-1.24	13.81	-16.6
60.0	72.4	79.5	-1.3	17.4	-5.5	-6.2	0.0	-0.0	-10.95	12.19	-16.7
70.0	72.0	79.8	-1.3	17.4	-5.6	-6.2	-0.0	-0.0	-14.03	12.36	-16.6
80.0	70.8	79.8	-1.3	17.4	-5.6	-6.2	0.0	-0.0	-13.11	12.09	-16.7
90.0	72.8	79.9	-1.3	17.4	-5.6	-6.2	0.0	-0.0	-12.57	12.77	-16.7
100.0	71.2	79.9	-1.3	17.4	-5.5	-6.2	-0.0	-0.0	-12.41	12.88	-9.8
110.0	71.3	80.2	-1.3	17.5	-5.5	-6.4	-0.0	-0.0	-10.14	12.83	-28.3
120.0	71.0	80.3	-1.3	17.4	-5.5	-6.4	-0.0	-0.0	-12.25	13.33	-17.2
130.0	71.7	80.4	-1.3	17.4	-5.5	-6.2	0.0	0.0	-12.95	13.02	13.4
140.0	71.2	80.3	-1.0	17.4	-5.3	-6.1	0.0	0.0	-12.46	12.87	51.4
150.0	72.9	80.7	-0.9	17.5	-5.2	-6.1	0.2	0.2	-12.25	13.43	87.0
160.0	72.2	80.6	-0.8	17.5	-5.2	-6.1	0.1	0.4	-12.03	13.22	120.3
170.0	72.5	80.9	-0.8	17.5	-5.1	-6.0	0.3	0.8	-11.82	13.69	152.0
180.0	71.5	80.9	-0.6	17.5	-4.9	-5.9	0.1	0.5	-12.30	13.50	182.0
190.0	71.6	80.8	-0.5	17.5	-4.9	-5.9	0.2	0.6	-12.19	13.27	210.9
200.0	72.0	81.3	-0.5	17.5	-4.8	-5.9	0.2	0.5	-11.22	13.88	238.9
210.0	71.9	81.4	-0.4	17.5	-4.7	-5.8	0.3	0.5	-11.87	13.42	266.6
220.0	72.1	81.4	-0.3	17.5	-4.7	-5.7	0.2	0.7	-12.14	13.09	291.3
230.0	73.1	81.6	-0.2	17.5	-4.6	-5.5	0.3	0.7	-11.71	13.13	316.3
240.0	71.5	81.6	-0.2	17.5	-4.5	-5.4	0.3	0.4	-11.28	12.92	340.0
250.0	71.2	81.8	-0.1	17.5	-4.4	-5.3	0.3	0.3	-11.87	12.90	363.1
260.0	71.4	81.8	0.0	17.5	-4.3	-5.3	0.1	0.2	-11.76	13.14	384.7
270.0	71.3	81.9	0.2	17.5	-4.2	-5.2	0.0	0.2	-11.60	12.91	406.6
280.0	72.8	82.3	0.3	17.5	-4.2	-5.1	0.1	0.2	-11.33	13.19	425.9
290.0	72.5	82.6	0.4	17.5	-4.1	-5.0	0.0	0.1	-11.11	12.75	446.3

RS-31 FLYWHEEL TEST — ID:F9 — TAPE 357

DATA INTERVAL IS 10 SECONDS — 11/13/79 15:05:44 — FILE 06

CHANNEL	52	53	54	55	56	57	58	59	62	15	10
	M9	M10	M26	M27	M28	M29	M31	M32	M56	M57	
TIME	LFCAVT	AOT	RF GAP	LF GAP	RR GAP	LR GAP	LF VIB	RR VIB	BIAP	BTOP	TIME
SEC	DEG F	DEG F	PICO F	PICO F	PICO F	PICO F	G	G	PSIG	PSIG	PULSE
300.0	71.8	82.6	0.3	17.5	-4.2	-5.1	0.0	0.0	-11.38	13.03	435.9
310.0	71.3	82.8	0.2	17.5	-4.2	-5.2	0.0	-0.0	-11.71	12.47	447.9
320.0	72.4	83.3	0.2	17.5	-4.3	-5.2	0.0	-0.0	-11.65	13.28	443.4
330.0	73.4	83.3	0.1	17.4	-4.4	-5.3	0.0	0.0	-11.01	13.28	438.8
340.0	72.0	83.4	0.1	17.5	-4.4	-5.3	0.0	0.0	-11.44	12.56	434.4
350.0	73.7	83.8	0.1	17.5	-4.4	-5.3	0.0	0.0	-11.98	13.72	429.7
360.0	71.3	84.1	0.0	17.5	-4.4	-5.4	-0.0	-0.0	-11.71	12.67	425.0
370.0	73.1	84.8	0.1	17.5	-4.4	-5.3	0.0	0.0	-11.44	12.97	420.6
380.0	72.4	85.1	0.1	17.5	-4.4	-5.4	0.0	-0.0	-11.28	12.93	416.3
390.0	72.4	85.4	0.1	17.5	-4.5	-5.4	0.0	0.0	-10.90	13.53	411.6
400.0	71.7	85.7	-0.0	17.5	-4.5	-5.5	0.0	0.0	-11.38	12.34	406.3
410.0	73.6	86.0	-0.0	17.4	-4.6	-5.5	0.0	0.0	-11.28	13.20	399.4
420.0	73.5	86.6	-0.1	17.4	-4.6	-5.6	0.0	0.0	-11.32	13.03	385.0
430.0	73.1	86.8	-0.0	17.5	-4.6	-5.5	0.0	0.0	-12.19	13.59	380.3
440.0	72.2	87.6	-0.0	17.5	-4.6	-5.5	-0.0	-0.1	-11.65	12.33	376.3
450.0	72.5	87.8	-0.0	17.5	-4.6	-5.5	0.0	0.0	-10.90	13.06	371.9
460.0	72.8	88.4	-0.1	17.5	-4.6	-5.6	0.0	-0.0	-11.76	13.13	366.1
470.0	72.7	88.7	-0.1	17.5	-4.7	-5.6	0.0	0.0	-11.76	12.98	360.7
480.0	73.5	88.9	-0.2	17.5	-4.7	-5.7	0.0	0.0	-8.31	12.34	375.1
490.0	72.9	89.5	-0.2	17.5	-4.7	-5.7	0.0	-0.0	-7.12	8.96	353.1
500.0	72.6	89.6	-0.0	17.5	-4.8	-5.7	0.0	0.0	-1.02	7.99	333.4
510.0	73.7	90.0	-0.4	17.5	-5.0	-5.9	1.0	0.2	84.51	22.72	313.4
520.0	72.0	90.3	-0.6	17.5	-5.1	-6.1	1.0	0.1	83.54	22.31	292.8
530.0	73.9	90.8	-0.8	17.5	-5.3	-6.3	0.9	0.1	82.57	23.56	157.0
540.0	72.3	91.1	-0.6	17.5	-5.7	-6.4	0.8	0.0	82.79	24.27	104.2
550.0	73.8	91.5	-1.0	17.5	-5.5	-6.4	0.7	0.1	81.49	24.27	44.9
560.0	72.4	91.6	-1.0	17.5	-5.5	-6.4	0.0	0.0	-4.69	10.63	32.3
570.0	71.4	91.8	-1.1	17.5	-5.5	-6.4	0.0	-0.0	-3.99	11.31	30.9
580.0	71.3	92.2	-1.0	17.5	-5.5	-6.4	0.0	-0.0	-3.61	11.36	29.4
590.0	73.4	92.3	-1.1	17.5	-5.5	-6.4	0.0	-0.0	-4.58	12.48	27.8

RS-31 FLYWHEEL TEST ID:FW 5 TAPE 357

DATA INTERVAL IS 10 SECONDS 11/13/79 15:10:44 FILE 06

CHANNEL	52	53	54	55	56	57	58	59	62	15	10
	M9	M10	M26	M27	M28	M29	M31	M32	M56	M57	
TIME	LFCAVT	AOT	RF GAP	LF GAP	RR GAP	LR GAP	LF VIB	RR VIB	RTAP	RTOP	TIME
SEC	DEG F	DEG F	PICO F	PICO F	PICO F	PICO F	G	G	PSIG	PSIG	PULSE
600.0	72.2	92.6	-1.0	17.5	-5.5	-6.4	0.0	0.0	-4.48	12.73	26.4
610.0	71.4	92.8	-1.0	17.5	-5.5	-6.4	0.0	-0.0	-3.77	12.55	25.2
620.0	72.5	93.3	-1.0	17.5	-5.5	-6.4	0.0	-0.0	-4.75	13.05	23.9

RS-31 FLYWHEEL TEST ID:FW 1 TAPE 357

DATA INTERVAL IS 10 SECONDS 11/13/79 15:00:55 FILE 06

CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
0.0	15.6	59.4	72.2	76.6
10.0	14.1	60.9	75.0	78.4
20.0	14.1	59.4	73.1	73.1
30.0	14.1	60.9	71.6	79.5
40.0	17.2	60.9	68.1	74.0
50.0	15.6	62.5	76.9	75.9
60.0	14.1	59.4	66.4	76.0
70.0	14.1	59.4	66.6	75.3
80.0	18.8	62.5	71.7	78.4
90.0	14.1	59.4	75.3	79.2
100.0	14.1	60.9	69.2	74.9
110.0	31275.0	54.7	65.7	79.1
120.0	30800.0	54.7	68.4	78.1
130.0	2143.8	-17.2	70.7	77.1
140.0	201.6	73.4	71.8	75.2
150.0	1.6	2448.4	73.1	78.2
160.0	4921.9	-782.8	77.0	77.5
170.0	-218.8	5331.3	72.1	80.9
180.0	-482.8	3690.6	73.0	81.8
190.0	5306.3	487.5	75.9	77.8
200.0	2582.8	4009.4	67.3	77.4
210.0	828.1	4196.9	73.8	81.4
220.0	4046.9	1292.2	74.0	78.0
230.0	4609.4	1801.6	71.9	77.9
240.0	2271.9	4700.0	75.1	80.4
250.0	3143.8	4025.0	69.6	80.4
260.0	4275.0	3440.6	72.8	76.5
270.0	4834.4	4021.9	75.1	83.2
280.0	4084.4	5081.3	73.7	82.8
290.0	4937.5	4612.5	78.4	79.9

RS-31 FLYWHEEL TEST — TEST 2 — TAPE 357

DATA INTERVAL IS 10 SECONDS — 11/13/79 15:05:40 — FILE 06

CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
300.0	4871.9	4981.3	77.1	79.8
310.0	5115.6	5103.1	71.4	81.3
320.0	5096.9	5068.8	74.9	80.9
330.0	3631.3	4240.6	73.9	80.3
340.0	4596.9	4375.0	77.3	83.0
350.0	3346.9	3637.5	79.0	80.7
360.0	4909.4	4703.1	73.1	84.1
370.0	4650.0	3462.5	79.5	82.8
380.0	4056.3	3437.5	74.1	84.7
390.0	4900.0	4600.0	79.3	85.6
400.0	4800.0	3521.9	72.5	83.6
410.0	4371.9	3025.0	79.1	82.9
420.0	4653.1	3640.6	77.1	85.7
430.0	4062.5	2887.5	75.8	86.1
440.0	2759.4	3556.3	77.3	88.8
450.0	2740.6	4059.4	79.0	87.8
460.0	4343.8	3184.4	74.3	88.3
470.0	4337.5	2643.8	81.1	88.1
480.0	3615.6	4446.9	75.8	83.7
490.0	3850.0	4712.5	78.6	89.4
500.0	2662.5	2515.6	80.2	84.6
510.0	4696.9	1831.3	80.4	89.2
520.0	1704.7	-146.9	80.9	89.2
530.0	-92.2	5706.3	82.7	85.9
540.0	159.4	2209.4	78.4	91.8
550.0	17.2	68.8	84.5	90.2
560.0	15.6	217.2	82.6	92.0
570.0	9.4	37.5	76.9	86.6
580.0	-662.5	3987.5	81.1	92.1
590.0	14.1	245.3	81.8	90.3

CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
600.0	-51.6	62.5	82.6	88.4
610.0	12.5	62.5	76.8	88.3
620.0	-14.1	-9.4	78.3	89.0

TEST F1

RS-31 FLYWHEEL TEST — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:26:1[illegible] — FILE 01

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	M1	M51	M50
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	RFCAV T	FUG SPD	PB VAC	LB VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
0.0	0.00	0.00	0.00	0.00	14.6	14.7	65.8	0.0	14.70	-1.45
10.0	0.00	0.00	0.01	0.00	14.7	14.7	65.8	0.0	14.70	-1.41
20.0	0.73	8.00	0.00	0.00	12.3	11.9	65.8	0.0	14.63	-1.40
30.0	0.94	7.93	0.00	0.00	8.8	8.4	65.8	0.6	14.61	-1.33
40.0	1.06	8.07	0.01	0.00	6.3	6.0	65.7	-0.6	14.79	-1.29
50.0	1.13	8.11	1.15	0.00	4.6	4.3	65.8	-1.1	14.76	-1.32
60.0	1.15	8.14	1.31	0.00	3.4	3.1	65.8	0.0	14.58	-1.36
70.0	1.16	8.17	1.39	0.00	2.6	2.1	65.7	0.0	14.78	-1.33
80.0	1.16	8.18	1.45	0.00	2.0	1.5	65.8	0.6	5.91	-1.37
90.0	1.16	8.13	1.45	0.00	1.4	1.0	65.8	-0.6	0.79	-1.23
100.0	1.12	8.12	1.44	0.00	1.1	0.7	65.7	-0.6	1.92	-1.32
110.0	1.09	8.10	1.44	0.00	0.9	0.4	65.8	-0.6	3.30	-1.29
120.0	1.06	8.03	1.44	0.00	0.7	0.3	65.8	0.0	3.91	-1.42
130.0	1.04	8.04	1.48	0.00	0.7	0.1	65.8	0.6	4.47	-1.38
140.0	1.03	8.00	1.49	0.00	0.4	0.0	65.8	0.0	4.78	-1.35
150.0	1.03	7.92	1.46	0.00	0.3	-0.0	65.8	-1.1	5.22	-1.30
160.0	1.02	7.91	1.44	0.00	0.4	-0.1	65.7	5211.0	5.43	-1.35
170.0	1.03	7.98	1.48	0.00	0.4	-0.2	65.7	6669.0	5.49	-1.1[illegible]
180.0	1.04	7.93	1.49	0.00	0.3	-0.0	65.8	11115.0	5.34	-1.32
190.0	1.03	7.92	1.45	0.00	0.5	-0.2	65.8	11223.0	5.38	-1.31
200.0	1.03	7.86	1.49	0.00	0.6	-0.1	65.8	12420.0	5.58	-1.36
210.0	1.03	7.86	1.48	0.68	0.0	-0.2	65.8	12879.0	5.53	-1.32
220.0	1.04	7.77	1.46	0.94	0.5	-0.3	65.7	12924.0	5.56	-1.25
230.0	1.04	7.73	1.50	1.09	0.2	-0.2	65.8	13320.0	5.61	-1.31
240.0	1.04	7.51	1.52	1.21	0.0	-0.2	65.8	13356.0	5.51	-1.31
250.0	1.05	7.50	1.47	1.55	0.0	-0.2	65.8	13527.0	5.36	-1.35
260.0	1.04	7.31	1.45	1.70	0.2	-0.2	65.8	13572.0	5.34	-1.32
270.0	1.05	7.46	1.49	1.93	0.3	-0.2	65.8	13653.0	5.21	-1.3[illegible]
280.0	1.05	7.24	1.48	1.63	0.2	-0.4	65.8	13905.0	5.33	-1.24
290.0	1.06	7.36	1.45	1.90	0.2	-0.3	65.8	13905.0	5.2[illegible]	-1.1[illegible]

Up to 14500 drift to 11000 up to 14500 - BRAKE TO A STOP

RS-31 FLYWHEEL TEST TD:[illegible] 2 TAPE 351

DATA INTERVAL IS 10 SECONDS 11/26/79 17:31:[illegible] FILE 01

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	N1	M51	M52
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	RECAV T	ENG SPD	PB VAC	TB VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
300.0	1.06	7.46	1.55	2.17	0.7	-0.2	65.8	14049.0	5.11	-1.15
310.0	1.07	7.43	6.52	1.88	0.2	-0.3	65.9	14085.0	5.00	-1.29
320.0	1.09	7.47	12.16	1.93	0.0	-0.2	65.9	14310.0	4.86	-1.13
330.0	1.08	7.17	12.80	1.96	0.8	-0.0	65.9	14301.0	4.98	-1.12
340.0	1.08	7.37	13.69	2.04	0.3	-0.1	66.0	14166.0	4.85	-1.01
350.0	1.12	7.37	14.29	2.22	0.1	-0.2	65.9	13644.0	4.81	-0.70
360.0	1.07	7.34	15.16	2.15	0.2	-0.0	66.0	13626.0	4.84	-1.15
370.0	1.36	7.21	11.99	2.15	-0.2	-0.1	66.0	13617.0	5.18	-0.99
380.0	1.35	7.35	13.60	2.19	-0.3	-0.2	66.1	13617.0	4.72	-1.01
390.0	1.16	7.33	16.35	2.05	0.3	-0.3	66.1	13608.0	4.96	-1.17
400.0	1.45	7.28	17.95	2.15	0.3	-0.3	66.2	13383.0	4.78	-1.32
410.0	1.12	5.70	15.08	2.13	1.7	-0.0	66.4	13383.0	4.73	-1.68
420.0	1.51	7.33	13.51	2.35	-0.4	-0.3	66.5	13383.0	4.52	-1.61
430.0	1.22	7.31	12.69	2.28	2.5	0.0	66.6	13023.0	5.40	-1.45
440.0	1.58	7.51	12.98	2.46	-1.5	-0.3	66.6	11115.0	4.51	-1.50
450.0	1.25	7.48	13.01	2.53	0.7	0.0	66.8	11025.0	5.46	-1.70
460.0	1.24	7.50	13.20	2.72	0.7	0.0	66.9	11979.0	5.31	-1.61
470.0	1.27	7.55	13.05	2.78	0.3	-0.2	67.3	12609.0	4.46	-1.81
480.0	1.27	7.46	12.85	2.91	0.6	-0.2	67.4	13149.0	4.55	-2.07
490.0	1.27	7.43	11.86	3.01	-1.1	-0.0	67.5	13149.0	5.31	-3.71
500.0	1.30	7.52	11.46	2.99	3.9	0.2	67.8	12249.0	5.20	-2.89
510.0	1.30	7.50	11.29	3.07	3.2	0.1	68.0	11754.0	5.35	-2.71
520.0	1.30	7.53	11.64	3.14	3.3	-0.1	68.3	11862.0	4.57	-2.77
530.0	1.31	7.50	10.94	3.26	-1.8	0.0	68.5	12798.0	5.26	-2.99
540.0	1.32	7.49	11.26	3.21	-0.8	-0.1	68.7	13374.0	5.40	-2.25
550.0	1.33	7.50	15.45	3.38	-2.8	-0.1	68.9	13383.0	4.40	-2.19
560.0	1.35	7.47	15.23	3.35	0.7	-0.3	69.3	13230.0	4.86	-2.32
570.0	1.32	7.49	13.85	3.40	-2.3	-0.1	69.6	13068.0	3.94	-2.00
580.0	1.34	7.47	13.64	3.41	-2.2	-0.0	69.8	13644.0	3.47	-5.59
590.0	1.36	7.54	13.30	3.61	2.0	-0.2	70.1	13185.0	3.70	1.05

RS-31 FLYWHEEL TEST

DATA INTERVAL IS 10 SECONDS

11/26/79 17:36:[illegible]

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	N1	M51	M54
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	RECAV T	ENG SPD	FB VAC	LB VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
600.0	1.36	7.54	12.11	3.57	-2.8	-0.3	70.3	13167.0	5.2[illegible]	1.2[illegible]
610.0	1.40	7.52	11.90	3.68	-0.1	-0.4	70.6	12195.0	3.69	-1.62
620.0	1.40	7.50	16.70	3.65	-0.8	-0.2	70.9	10053.0	3.54	-2.17
630.0	1.39	7.40	12.60	3.63	0.8	-0.2	71.2	9180.0	6.74	-3.1[illegible]
640.0	1.41	7.47	12.64	3.77	-0.7	-0.3	71.5	9189.0	3.40	-4.41
650.0	1.42	7.45	12.30	3.72	2.7	-0.4	71.8	9189.0	5.02	-5.6[illegible]
660.0	1.41	6.37	12.75	3.85	5.4	-0.5	72.2	9171.0	4.09	-1.7[illegible]
670.0	1.40	7.43	12.79	3.83	0.2	-0.4	72.5	9171.0	4.65	-1.6[illegible]
680.0	1.42	7.54	12.55	3.93	-0.4	-0.3	72.9	9162.0	5.16	-1.61
690.0	1.36	7.55	12.33	3.78	0.7	-0.3	73.1	9162.0	4.23	-1.7[illegible]
700.0	1.38	7.52	12.35	3.99	6.4	-0.3	73.4	9162.0	4.9[illegible]	-1.4[illegible]
710.0	1.41	7.60	12.44	4.00	1.1	-0.3	73.7	9162.0	5.11	-1.8[illegible]
720.0	1.40	7.53	11.54	4.07	0.9	-0.3	74.0	9171.0	5.2[illegible]	-9.9[illegible]
730.0	1.44	7.58	12.10	3.98	0.4	-0.5	74.4	9135.0	4.9[illegible]	-6.5[illegible]
740.0	1.41	7.58	12.51	4.03	-0.2	-0.6	74.8	9117.0	5.05	-3.5[illegible]
750.0	1.37	7.57	10.78	4.02	0.3	-0.3	75.1	9126.0	4.85	2.0[illegible]
760.0	1.44	7.52	11.15	4.11	-0.0	-0.6	75.3	9126.0	4.87	6.0[illegible]
770.0	1.44	7.57	10.98	4.05	0.9	-0.5	75.6	9117.0	4.9[illegible]	25.[illegible]
780.0	1.46	7.57	11.71	4.04	0.8	-0.5	75.8	9135.0	4.96	14.7[illegible]
790.0	1.46	7.63	10.89	4.10	-0.5	-0.6	76.2	9117.0	5.2[illegible]	53.9[illegible]
800.0	1.46	7.26	12.19	4.04	-0.7	-0.7	76.4	9117.0	5.09	2.2[illegible]
810.0	1.47	7.63	10.74	4.12	0.8	-0.5	76.8	9117.0	5.2[illegible]	7.6[illegible]
820.0	1.49	5.92	10.74	4.15	-0.9	-0.5	77.0	9117.0	5.06	4.0[illegible]
830.0	1.48	7.52	11.91	4.13	1.2	-0.5	77.3	8847.0	5.01	2.51
840.0	1.49	7.62	12.31	4.16	-0.0	-0.7	77.6	9270.0	5.0[illegible]	-1.1[illegible]
850.0	1.47	7.64	9.46	4.23	0.5	-0.5	77.9	8595.0	4.9[illegible]	-1.[illegible]
860.0	1.48	7.61	8.36	4.14	0.3	-0.8	78.1	8604.0	5.2[illegible]	-1.70
870.0	1.47	7.65	10.26	3.98	0.9	-0.6	78.3	8604.0	5.23	0.5[illegible]
880.0	1.47	7.58	11.08	4.07	1.1	-0.7	78.6	8604.0	5.11	0.0[illegible]
890.0	1.49	7.65	8.38	3.97	-0.2	-0.7	78.9	8595.0	5.1[illegible]	1.3[illegible]

PS-51 FLYWHEEL TEST 10:[illegible] 4 TAPE 351

DATA INTERVAL IS 10 SECONDS 11/26/79 17:41:0[illegible] FILE 01

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	N1	M51	M54
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	PFCAV T	FUG SPD	RB VAC	LB VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
900.0	1.48	7.69	9.83	4.03	0.1	-0.6	79.1	8586.0	5.16	-1.67
910.0	1.48	7.69	8.96	4.09	-0.4	-0.7	79.4	8595.0	5.38	-1.60
920.0	1.48	7.69	9.23	4.06	0.6	-0.6	79.7	8568.0	5.16	-1.60
930.0	1.46	7.72	9.70	4.04	-0.2	-0.8	79.9	8559.0	5.22	-1.66
940.0	1.48	7.69	11.51	3.93	1.0	-0.6	80.1	8550.0	5.44	-1.65
950.0	1.49	7.63	9.63	4.05	0.1	-0.7	80.4	8568.0	5.16	-1.58
960.0	1.46	7.65	8.34	4.12	1.0	-0.8	80.6	8568.0	5.34	-1.66
970.0	1.47	7.67	9.08	3.92	-1.3	-0.8	80.8	8559.0	5.23	-1.60
980.0	1.45	7.39	7.68	4.07	0.3	-0.7	81.1	8559.0	5.34	-1.74
990.0	1.48	7.71	11.40	4.06	1.3	-0.8	81.4	10854.0	5.32	-1.61
1000.0	1.45	7.58	11.46	4.15	-0.7	-0.7	81.6	12366.0	5.04	-1.74
1010.0	1.46	7.60	13.28	4.13	-0.0	-0.6	81.8	13896.0	5.36	-1.63
1020.0	1.47	7.61	14.23	4.19	0.4	-0.8	82.1	14193.0	5.34	-1.67
1030.0	1.43	7.51	12.29	4.06	0.8	-0.7	82.3	14643.0	5.43	-1.63
1040.0	1.45	7.50	14.79	4.14	0.5	-0.8	82.6	14490.0	5.33	-1.66
1050.0	1.43	7.47	11.68	4.17	-1.7	-0.9	82.8	14310.0	5.23	-1.69
1060.0	1.43	7.42	13.25	4.21	-1.1	-0.6	83.1	14319.0	5.40	-1.52
1070.0	1.45	7.40	13.31	4.23	2.5	-0.7	83.4	13518.0	7.12	-1.52
1080.0	1.45	7.45	13.46	4.23	2.4	-0.8	83.6	13194.0	4.02	-1.66
1090.0	1.44	7.34	13.40	4.28	3.1	-0.9	83.9	13194.0	3.99	-1.69
1100.0	1.47	7.46	13.16	4.25	-1.2	-0.8	84.3	13194.0	4.95	-1.55
1110.0	1.45	7.34	11.86	4.35	1.2	-0.8	84.5	13194.0	4.36	-1.49
1120.0	1.46	7.40	11.78	4.26	0.6	-0.7	84.8	12492.0	5.46	1.45
1130.0	1.46	7.35	12.13	4.26	-1.9	-0.7	85.3	12483.0	5.67	1.29
1140.0	1.42	7.30	11.86	4.35	-0.2	-0.9	85.6	12438.0	5.14	0.69
1150.0	1.46	7.44	12.08	4.24	-1.7	-0.9	85.9	12447.0	6.14	-0.07
1160.0	1.42	7.43	12.14	4.35	-0.9	-0.9	86.3	12456.0	6.09	-0.12
1170.0	1.45	7.36	12.25	4.25	-1.5	-0.9	86.6	12438.0	6.15	-0.15
1180.0	1.47	7.39	12.26	4.28	1.7	-0.8	87.1	12348.0	4.80	-0.21
1190.0	1.45	7.35	12.20	4.30	-1.6	-1.0	87.5	12330.0	6.31	-0.35

PS-51 FLYWHEEL TEST — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:41:0[illegible] — FILE 01

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	N1	M51	M52
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	PFCAV T	ENG SPD	PB VAC	LB VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
900.0	1.48	7.69	9.83	4.03	0.1	-0.6	79.1	8586.0	5.16	-1.67
910.0	1.48	7.69	8.96	4.09	-0.4	-0.7	79.4	8595.0	5.38	-1.60
920.0	1.48	7.69	9.23	4.06	0.6	-0.6	79.7	8568.0	5.16	-1.60
930.0	1.46	7.72	9.70	4.04	-0.2	-0.8	79.9	8559.0	5.22	-1.66
940.0	1.48	7.69	11.51	3.93	1.0	-0.6	80.1	8550.0	5.40	-1.65
950.0	1.49	7.63	9.63	4.05	0.1	-0.7	80.4	8568.0	5.16	-1.59
960.0	1.46	7.65	8.34	4.12	1.0	-0.8	80.6	8568.0	5.38	-1.66
970.0	1.47	7.67	9.08	3.92	-1.3	-0.8	80.8	8559.0	5.23	-1.60
980.0	1.45	7.39	7.68	4.07	0.3	-0.7	81.1	8559.0	5.34	-1.73
990.0	1.48	7.71	11.40	4.06	1.3	-0.8	81.4	10854.0	5.32	-1.61
1000.0	1.45	7.58	11.46	4.15	-0.7	-0.7	81.6	12366.0	5.04	-1.73
1010.0	1.46	7.60	13.28	4.13	-0.0	-0.6	81.8	13896.0	5.36	-1.63
1020.0	1.47	7.61	14.23	4.19	0.4	-0.8	82.1	14193.0	5.34	-1.67
1030.0	1.43	7.51	12.29	4.06	0.8	-0.7	82.3	14643.0	5.43	-1.63
1040.0	1.45	7.50	14.79	4.14	0.5	-0.8	82.6	14490.0	5.33	-1.66
1050.0	1.43	7.47	11.68	4.17	-1.7	-0.9	82.8	14310.0	5.23	-1.64
1060.0	1.43	7.42	13.25	4.21	-1.1	-0.6	83.1	14319.0	5.40	-1.52
1070.0	1.45	7.40	13.31	4.23	2.5	-0.7	83.4	13518.0	7.12	-1.52
1080.0	1.45	7.45	13.46	4.23	2.4	-0.8	83.6	13194.0	4.02	-1.66
1090.0	1.44	7.34	13.40	4.28	3.1	-0.9	83.9	13194.0	3.99	-1.64
1100.0	1.47	7.46	13.16	4.25	-1.2	-0.8	84.3	13194.0	4.95	-1.55
1110.0	1.45	7.34	11.86	4.35	1.2	-0.8	84.5	13194.0	4.36	-1.49
1120.0	1.46	7.40	11.78	4.26	0.6	-0.7	84.8	12492.0	5.46	1.45
1130.0	1.46	7.35	12.13	4.26	-1.9	-0.7	85.3	12483.0	5.67	1.26
1140.0	1.42	7.30	11.86	4.35	-0.2	-0.9	85.6	12438.0	5.04	0.68
1150.0	1.46	7.44	12.08	4.24	-1.7	-0.9	85.9	12447.0	6.14	-0.07
1160.0	1.42	7.43	12.14	4.35	-0.9	-0.9	86.3	12456.0	6.09	-0.18
1170.0	1.45	7.36	12.25	4.25	-1.5	-0.9	86.6	12438.0	6.15	-0.15
1180.0	1.47	7.39	12.26	4.28	1.7	-0.8	87.1	12348.0	4.80	-0.21
1190.0	1.45	7.35	12.20	4.30	-1.6	-1.0	87.5	12330.0	6.31	-0.35

RS-31 FLYWHEEL TEST — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:46:[illegible] — FILE 01

CHANNEL	1	3	5	6	7	8	11	16	69	70
	M49	M50	M59	M60	A6	A7	M8	N1	M51	M54
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	RECAV T	ENG SPD	RB VAC	LR VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
1200.0	1.45	7.12	11.99	4.32	1.5	-0.9	87.9	12321.0	5.37	-0.92
1210.0	1.49	7.32	12.33	4.31	-0.7	-0.9	88.4	12330.0	6.08	-0.50
1220.0	1.45	7.34	12.34	4.35	0.8	-0.9	88.8	12501.0	5.35	-0.27
1230.0	1.47	7.43	12.10	4.41	-1.1	-0.9	89.2	12474.0	6.28	-0.42
1240.0	1.53	7.35	12.43	4.43	-0.5	-0.8	89.6	12483.0	5.73	-0.47
1250.0	1.47	7.26	12.05	4.34	2.2	-0.9	90.0	12483.0	4.60	-0.65
1260.0	1.52	7.32	12.15	4.32	-0.8	-0.9	90.5	12402.0	5.21	-1.03
1270.0	1.52	7.27	12.40	4.39	-0.7	-1.0	90.9	12402.0	5.82	-0.98
1280.0	1.52	7.33	12.15	4.38	0.9	-0.9	91.5	12384.0	4.55	-0.97
1290.0	1.52	7.21	12.53	4.48	1.0	-1.0	91.9	12393.0	4.74	-0.67
1300.0	1.54	7.31	12.54	4.43	2.3	-1.0	92.4	12393.0	4.62	-0.93
1310.0	1.54	7.30	12.66	4.44	-0.3	-0.9	92.9	12546.0	6.21	-0.81
1320.0	1.54	7.33	12.49	4.43	0.9	-0.8	93.3	12564.0	4.85	-0.47
1330.0	1.54	7.32	12.71	4.42	-1.2	-0.7	93.8	12564.0	6.13	-0.33
1340.0	1.54	7.06	12.75	4.47	0.0	-0.9	94.3	12447.0	6.12	-1.52
1350.0	1.54	7.36	12.76	4.46	-1.3	-1.0	94.8	12438.0	6.38	-1.53
1360.0	1.53	7.30	12.85	4.49	-1.2	-1.0	95.2	12438.0	6.29	-1.56
1370.0	1.54	7.16	12.88	4.42	0.7	-1.0	95.8	12447.0	5.10	-1.53
1380.0	1.53	7.37	13.16	4.47	1.8	-1.0	96.3	12447.0	4.64	-1.54
1390.0	1.54	7.34	13.16	4.54	1.6	-0.9	96.8	12447.0	5.46	-1.60
1400.0	1.54	7.19	13.09	4.47	2.1	-0.9	97.3	12330.0	4.57	-1.62
1410.0	1.54	7.37	10.58	4.42	1.9	-1.0	97.8	8919.0	4.95	-1.65
1420.0	1.56	7.46	1.63	2.18	-1.4	-1.0	98.3	3.4	4.74	-1.76
1430.0	1.61	7.43	1.58	1.22	-0.4	-1.0	98.8	1.1	16.66	-1.78
1440.0	1.58	7.65	1.16	0.91	-0.2	-0.7	99.4	1.1	17.43	-1.55
1450.0	1.59	7.79	1.19	1.17	0.7	-0.4	99.9	1.7	17.49	-1.50
1460.0	1.60	7.88	1.10	1.69	1.3	-0.2	100.6	1.1	17.43	-1.59
1470.0	1.61	7.92	1.16	2.48	0.6	0.0	101.1	0.0	17.66	-1.59
1480.0	1.59	7.96	1.22	4.21	2.2	0.3	101.6	0.6	17.59	-1.53
1490.0	1.61	7.94	1.17	4.62	1.8	0.3	102.3	0.6	17.66	-1.60

RS-31 FLYWHEEL TEST TEST # 6 TAPE 351

DATA INTERVAL IS 10 SECONDS 11/26/79 17:51:09 FILE 01

CHANNEL	1	3	5	6	7	8	11	16	69	79
	M49	M50	M59	M60	A6	A7	M8	N1	M51	M59
TIME	FOF	AOF	BOF	GBOF	RCAVP	LCAVP	RECAV T	ENG SPD	RB VAC	LP VAC
SEC	GPM	GPM	GPM	GPM	PSIA	PSIA	DEG F	RPM	PSIA	PSIA
1500.0	1.62	7.99	1.18	4.15	1.3	0.3	102.9	-0.6	17.50	-1.34
1510.0	1.61	8.03	1.19	3.56	2.5	0.3	103.1	-0.6	17.83	-1.63
1520.0	1.61	8.06	1.16	2.36	0.9	0.2	104.1	0.6	17.81	-1.67
1530.0	1.61	8.07	1.20	0.00	1.6	0.1	104.8	0.6	17.61	-1.67
1540.0	1.61	8.20	0.90	0.00	1.3	-0.1	105.1	-0.6	17.79	-1.69
1550.0	1.62	8.26	1.15	0.00	1.0	-0.4	105.6	0.6	17.54	-1.57
1560.0	1.62	8.34	1.20	0.00	1.4	-0.5	106.1	0.6	17.65	-1.65
1570.0	1.62	8.32	1.14	0.00	1.1	-0.7	106.6	0.6	17.60	-1.65
1580.0	1.63	8.32	1.17	0.00	0.7	-0.8	107.0	-0.6	17.74	-1.68
1590.0	1.64	8.35	1.21	0.00	1.1	-1.0	107.3	-0.6	17.89	-1.60
1600.0	1.64	8.40	1.18	0.00	0.6	-1.1	107.6	-0.6	17.88	-1.62
1610.0	1.64	8.35	1.66	0.00	0.4	-1.1	108.0	-0.6	15.64	-1.59
1620.0	1.64	8.32	1.63	0.00	0.5	-1.2	108.4	0.0	15.51	-1.65
1630.0	1.64	8.35	1.68	0.00	0.4	-1.2	108.5	0.6	15.53	-1.55

RS-31 FLYWHEEL TEST — TDF# 1 — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:26:19 — FILE 01

CHANNEL	12	13	14	17	18	19	20	10	50	51
	M22	M23	M24	M4	M5	M6	M7	M1	M2	M3
TIME	FOP	AOP	GBOP	RRBRT	LRBRT	RFBRT	LFFRT	RH SPEED	LH SPEED	GR SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
0.0	-0.4	-2.8	-0.0	70.4	67.9	68.3	68.7	-1.6	40.6	-22.4
10.0	-0.4	-2.4	0.2	70.4	67.9	68.3	68.7	-3.1	39.1	-20.3
20.0	168.5	611.5	-0.0	71.1	68.4	68.3	68.7	-1.6	75.0	-60.1
30.0	168.6	508.5	0.0	75.6	70.6	69.1	70.0	-1.6	70.3	-62.5
40.0	166.9	492.0	0.1	78.1	71.9	71.7	71.9	-1.6	-29.7	60.9
50.0	165.3	487.0	-0.0	81.1	80.9	74.7	74.7	-1.6	-59.4	67.2
60.0	162.9	498.5	0.2	81.7	81.7	75.9	77.4	-1.6	39.1	-31.3
70.0	164.0	508.0	0.0	82.1	80.1	76.7	78.8	-1.6	3.1	15.6
80.0	162.3	523.0	-0.0	83.9	80.3	76.8	77.6	-1.6	71.9	-50.0
90.0	161.3	533.0	0.2	81.9	80.0	76.8	78.6	-1.6	-43.8	37.5
100.0	161.3	531.0	0.0	82.2	79.1	76.6	78.9	-1.6	-32.8	78.1
110.0	163.1	546.5	0.2	81.2	78.8	76.4	78.8	-1.6	-54.7	78.1
120.0	161.5	542.0	0.2	81.3	78.3	76.4	78.2	-1.6	37.5	-26.6
130.0	163.6	529.0	-0.2	81.0	78.3	76.4	77.8	-1.6	70.3	-59.4
140.0	162.3	542.0	0.2	81.3	78.3	76.5	77.7	-1.6	39.1	-26.6
150.0	164.1	524.5	0.0	80.8	78.4	76.5	77.6	-1.6	-48.4	59.4
160.0	162.5	514.5	-0.1	80.7	78.2	76.3	77.6	37.5	21.9	60.1
170.0	162.1	506.0	0.2	81.1	77.9	75.8	77.9	179.7	203.1	162.6
180.0	162.9	493.5	0.5	81.3	77.8	75.9	77.4	673.4	514.1	457.8
190.0	161.6	490.0	2.3	81.3	78.0	76.7	78.1	970.3	989.1	975.0
200.0	163.0	480.5	4.2	82.9	78.7	77.5	79.2	1615.6	1650.0	1620.7
210.0	163.0	480.0	6.3	85.7	80.4	79.3	80.3	2271.9	2234.4	2340.4
220.0	162.8	462.0	8.5	88.8	82.4	81.4	81.9	2943.8	2956.3	2981.3
230.0	161.9	468.5	10.0	92.8	85.6	83.7	84.1	3634.4	3570.1	3740.6
240.0	161.3	461.0	10.9	97.4	88.8	86.3	86.8	4328.1	4275.0	4453.1
250.0	161.5	463.0	14.4	97.9	95.3	88.9	89.4	5026.1	4978.1	5146.9
260.0	160.6	452.5	11.0	106.8	98.9	91.6	92.0	5718.8	5712.5	5793.8
270.0	160.9	471.5	17.2	113.5	104.3	94.1	96.8	6361.3	6450.0	6387.5
280.0	157.5	460.5	16.5	118.5	109.5	96.6	97.6	7081.3	7037.5	7212.5
290.0	161.5	479.5	18.3	123.4	113.1	98.2	100.1	7768.8	7743.8	7862.5

RS-31 FLYWHEEL TEST 40:FW 2 TAPE 251

DATA INTERVAL IS 10 SECONDS 11/26/79 17:31:01 FILE 01

CHANNEL	12	13	14	17	18	19	20	10	50	51
	M22	M23	M24	M4	M5	M6	M7	M1	M2	M3
TIME	FOP	AOP	GBOP	RRBRT	LRBRT	RFBPT	LFPRT	RH SPEED	LH SPEED	GR SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
300.0	160.9	500.0	14.2	130.5	120.5	100.8	102.6	8400.0	8437.5	8468.8
310.0	160.3	510.0	16.5	137.6	127.1	102.9	105.1	9050.0	9462.5	9081.3
320.0	159.8	534.0	14.9	143.1	134.4	105.1	107.9	9675.0	9687.5	9687.5
330.0	160.0	511.5	22.8	146.8	140.4	107.4	110.4	10312.5	10387.5	10362.5
340.0	160.1	532.0	21.2	151.0	142.4	108.6	113.0	10850.0	10850.0	10875.0
350.0	159.9	564.5	11.4	156.9	145.3	111.8	115.1	11325.0	11587.5	11462.5
360.0	157.1	562.0	10.8	159.8	151.0	113.8	116.9	11662.5	11650.0	11725.0
370.0	158.0	540.5	13.5	163.1	154.3	116.1	118.6	11975.0	11887.5	12100.0
380.0	159.6	566.5	17.5	167.4	154.6	116.4	120.4	12262.5	12262.5	12362.5
390.0	154.1	568.5	8.5	172.6	159.5	118.8	122.1	12550.0	14075.0	12700.0
400.0	152.8	567.5	12.8	178.9	163.5	118.6	123.9	12762.5	12875.0	12912.5
410.0	150.5	450.5	22.7	182.0	167.6	120.0	125.6	12962.5	13062.5	13050.0
420.0	152.9	556.0	20.0	185.3	168.9	122.4	126.6	13162.5	13200.0	13175.0
430.0	146.0	553.0	19.1	186.3	171.6	122.5	127.8	13312.5	13337.5	13375.0
440.0	151.6	538.5	20.7	187.3	173.9	124.1	128.5	13287.5	13237.5	13462.5
450.0	149.1	529.5	10.3	187.1	176.1	124.5	129.3	13200.0	13150.0	13300.0
460.0	145.9	513.0	16.0	189.9	177.5	125.9	130.1	13150.0	13175.0	13212.5
470.0	145.4	506.5	31.3	189.0	177.9	127.0	130.9	13200.0	13212.5	13287.5
480.0	142.6	505.0	20.7	191.4	179.1	127.1	131.8	13300.0	13462.5	13400.0
490.0	140.8	480.5	16.0	192.5	181.9	129.1	132.9	13437.5	13387.5	13562.5
500.0	139.6	496.0	23.8	194.1	182.6	128.6	134.1	13500.0	13437.5	13662.5
510.0	135.9	492.5	22.2	195.8	184.4	130.4	135.3	13475.0	13387.5	13600.0
520.0	133.6	498.0	25.3	196.8	185.5	131.0	136.4	13437.5	13487.5	13450.0
530.0	131.1	473.5	22.5	197.6	186.3	131.8	137.4	13500.0	13525.0	13550.0
540.0	128.3	464.5	25.9	199.5	187.5	133.8	138.1	13637.5	13750.0	13762.5
550.0	125.5	467.0	18.3	200.5	189.8	133.8	139.8	13800.0	13762.5	13912.5
560.0	123.9	480.5	26.3	202.9	191.8	134.5	141.1	13950.0	13962.5	13987.5
570.0	117.9	478.5	21.8	206.3	193.3	135.4	142.6	14062.5	14062.5	14162.5
580.0	118.8	471.5	20.9	206.0	195.4	136.9	144.1	14200.0	14150.0	14350.0
590.0	117.0	446.0	23.2	209.5	197.8	137.5	145.9	14362.5	14300.0	14537.5

RS-31 FLYWHEEL TEST TD:FW 5 TAPE 351

DATA INTERVAL IS 10 SECONDS 11/26/79 17:36:09 FILE 01

CHANNEL	12	13	14	17	18	19	20	10	50	51
	M22	M23	M24	M4	D5	M6	M7	M1	M2	D6
TIME	FOP	AOP	GBOP	RRBRT	LRBRT	RFBRT	LFBRT	RH SPEED	LH SPEED	GB SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
600.0	114.4	460.0	12.8	210.3	200.0	138.9	147.5	14462.5	14400.0	14637.5
610.0	115.9	455.0	19.6	211.8	201.8	140.0	148.8	14487.5	14500.0	14537.5
620.0	111.9	444.0	28.0	212.3	202.5	141.5	149.9	14362.5	14412.5	12687.5
630.0	109.9	419.5	24.9	211.5	202.5	142.0	151.1	14237.5	14237.5	11275.0
640.0	109.4	424.5	24.0	212.5	202.9	142.1	152.1	14112.5	14175.0	11162.5
650.0	105.4	430.5	21.5	211.5	203.5	143.9	153.4	14000.0	14012.5	11212.5
660.0	105.9	384.0	24.9	211.5	203.0	144.3	153.6	13887.5	13925.0	11200.0
670.0	103.9	402.5	21.5	211.5	203.0	145.6	155.3	13762.5	13737.5	11250.0
680.0	103.6	406.8	20.0	211.3	202.6	145.8	155.9	13650.0	13725.0	11150.0
690.0	96.9	399.0	16.8	210.5	202.5	146.4	156.8	13537.5	13562.5	11150.0
700.0	94.9	398.8	22.6	210.5	202.0	147.6	157.9	13437.5	13487.5	11150.0
710.0	96.5	385.8	15.9	210.5	202.3	147.5	158.6	13325.0	13300.0	11187.5
720.0	95.7	378.8	28.0	209.8	202.4	148.8	159.6	13212.5	13275.0	11162.5
730.0	95.1	365.0	19.9	209.8	202.0	149.3	160.6	13112.5	13212.5	11150.0
740.0	91.9	373.0	18.4	209.5	202.1	150.1	161.4	13012.5	13162.5	11050.0
750.0	88.9	347.8	22.3	209.3	202.8	151.3	162.4	12912.5	13037.5	11075.0
760.0	91.4	345.0	22.8	209.5	202.4	152.5	163.0	12812.5	12937.5	11037.5
770.0	91.8	359.5	20.1	209.5	201.6	152.4	163.9	12712.5	12850.0	11025.0
780.0	88.4	336.0	23.4	209.5	202.8	153.1	164.5	12625.0	12725.0	11137.5
790.0	87.6	343.8	21.2	209.0	202.4	153.6	165.5	12525.0	12650.0	11100.0
800.0	88.7	305.8	20.5	209.3	202.3	153.6	166.0	12425.0	12512.5	11187.5
810.0	88.6	339.3	20.8	209.0	202.4	153.9	166.8	12337.5	12462.5	11062.5
820.0	88.7	268.8	21.6	209.0	202.6	153.9	167.9	12250.0	12387.5	11062.5
830.0	86.6	321.3	19.8	208.5	202.4	155.4	167.9	12150.0	12300.0	10887.5
840.0	86.9	336.8	21.8	208.8	203.0	155.9	169.1	12062.5	12250.0	11237.5
850.0	85.3	316.5	19.5	208.5	202.1	157.0	169.5	11975.0	12137.5	10387.5
860.0	85.4	316.5	21.9	208.3	203.1	157.3	169.6	11887.5	12012.5	10412.5
870.0	84.0	306.5	16.8	208.0	203.0	157.1	170.6	11800.0	11975.0	10312.5
880.0	84.3	314.3	19.9	207.5	203.3	158.0	171.3	11712.5	11900.0	10337.5
890.0	85.3	316.8	17.0	207.8	203.3	158.9	171.6	11625.0	11787.5	10375.0

RS-31 FLYWHEEL TEST — ID:F1 4 — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:41:09 — FILE 01

CHANNEL	12	13	14	17	18	19	20	10	50	51
	M22	M23	M24	M4	M5	M6	M7	M1	M2	M3
TIME	FOP	AOP	GBOP	RRBRT	LRBRT	REBRT	LEBRT	RH SPEED	TP SPEED	GB SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
900.0	82.7	315.5	21.8	207.8	203.5	158.8	171.8	11537.5	11662.5	10362.5
910.0	83.0	308.0	17.4	207.3	203.1	159.5	172.4	11450.0	11562.5	10375.0
920.0	80.9	306.5	20.1	206.8	202.5	159.5	172.9	11362.5	11625.0	10287.5
930.0	81.3	310.0	17.7	206.3	201.9	160.3	173.1	11287.5	11412.5	10387.5
940.0	81.8	309.5	19.5	205.8	201.9	160.0	173.8	11200.0	11337.5	10375.0
950.0	82.0	297.5	21.6	205.8	201.4	160.6	173.9	11112.5	11300.0	10362.5
960.0	81.4	305.0	17.8	205.3	201.1	160.6	173.9	11037.5	11175.0	10362.5
970.0	80.6	306.8	20.0	204.8	201.0	160.8	174.1	10950.0	11137.5	10387.5
980.0	80.9	292.8	20.8	203.9	200.6	161.5	174.0	10875.0	11125.0	10312.5
990.0	79.8	295.0	22.7	203.8	199.9	161.4	174.1	10850.0	11062.5	10937.5
1000.0	80.1	323.3	20.0	203.8	199.0	160.9	173.9	11025.0	10987.5	11087.5
1010.0	79.4	332.0	17.0	204.3	198.6	161.3	175.5	11325.0	11262.5	11437.5
1020.0	80.3	343.3	24.3	205.3	197.5	161.9	175.5	11787.5	23450.0	11875.0
1030.0	79.3	344.0	21.9	207.5	197.0	161.9	176.9	12300.0	14375.0	12387.5
1040.0	80.8	341.0	20.9	210.5	195.0	161.9	178.1	12837.5	12850.0	12862.5
1050.0	78.1	370.8	21.1	213.3	193.5	161.5	179.6	13287.5	13262.5	13412.5
1060.0	79.2	385.8	24.3	216.3	195.1	162.6	181.3	13687.5	13662.5	13812.5
1070.0	79.3	393.8	21.0	220.3	195.0	163.4	183.5	14000.0	14000.0	14075.0
1080.0	79.9	367.8	19.3	222.0	194.0	164.3	184.1	14125.0	14050.0	14237.5
1090.0	78.6	363.5	21.6	223.0	196.8	165.9	185.0	14225.0	14175.0	14350.0
1100.0	79.5	378.5	24.7	224.3	197.5	165.6	186.8	14325.0	14362.5	14450.0
1110.0	80.6	356.0	22.9	225.5	198.6	165.6	187.4	14425.0	14350.0	14575.0
1120.0	79.2	380.8	23.8	226.3	199.3	166.5	188.1	14462.5	14425.0	14575.0
1130.0	78.4	389.0	22.0	227.8	202.8	168.0	189.4	14462.5	14475.0	14512.5
1140.0	77.3	393.3	22.6	227.8	205.3	168.0	189.3	14475.0	14375.0	14662.5
1150.0	79.1	386.0	21.1	228.3	205.0	168.3	190.6	14475.0	14450.0	14600.0
1160.0	76.6	407.3	24.3	229.0	205.8	169.1	191.1	14475.0	14462.5	14550.0
1170.0	79.2	392.3	21.4	229.3	205.5	169.6	192.3	14487.5	14462.5	14600.0
1180.0	78.4	380.8	21.8	229.5	207.0	170.1	193.1	14487.5	14400.0	14662.5
1190.0	76.1	398.0	21.7	230.0	208.8	170.5	194.1	14475.0	14487.5	14562.5

RS-31 FLYWHEEL TEST ID:[illegible] 5 TAPE 351

DATA INTERVAL IS 10 SECONDS 11/26/79 17:46:[illegible] FILE 01

CHANNEL	12	13	14	17	18	19	20	10	50	51
	M22	M23	M24	M4	M5	M6	M7	M1	M2	M3
TIME	FOP	AOP	GBOP	RRBRT	LRBRT	RFBRT	LFPRT	RH SPEED	LH SPEED	GR SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
1200.0	77.3	382.0	22.9	230.8	210.5	170.9	196.4	14462.5	14437.5	14575.0
1210.0	78.0	386.3	20.8	231.0	210.8	171.4	195.3	14450.0	14475.0	14487.5
1220.0	75.1	377.0	23.5	231.5	211.8	172.6	196.0	14462.5	14512.5	14487.5
1230.0	75.9	395.3	19.3	231.3	213.0	172.8	197.3	14462.5	14500.0	14500.0
1240.0	75.9	373.5	21.8	231.8	213.8	173.6	197.9	14475.0	14387.5	14612.5
1250.0	72.3	354.0	22.3	232.5	214.5	174.1	198.4	14487.5	14412.5	14650.0
1260.0	75.4	382.3	22.2	232.5	215.8	173.9	198.9	14487.5	14437.5	14587.5
1270.0	74.2	371.8	23.2	232.8	216.0	175.1	199.6	14487.5	14400.0	14637.5
1280.0	74.2	349.5	24.5	232.8	216.5	174.8	200.6	14475.0	14412.5	14637.5
1290.0	74.4	353.0	25.6	233.3	217.8	175.8	201.8	14475.0	14387.5	14675.0
1300.0	73.9	347.3	24.4	233.5	219.3	176.1	202.6	14475.0	14375.0	14625.0
1310.0	73.9	387.8	18.5	233.5	218.0	177.1	202.5	14462.5	14387.5	14587.5
1320.0	73.1	366.3	24.7	233.8	219.8	176.8	203.8	14475.0	14450.0	14562.5
1330.0	72.4	384.0	22.7	234.3	219.5	177.1	204.1	14500.0	14537.5	14512.5
1340.0	72.3	361.8	23.2	234.3	221.5	178.1	204.8	14500.0	14437.5	14637.5
1350.0	72.9	379.8	25.3	234.3	221.5	178.3	205.8	14500.0	14412.5	14625.0
1360.0	72.7	380.5	22.8	234.5	221.5	179.0	207.5	14500.0	14425.0	14637.5
1370.0	72.6	363.8	21.4	234.5	222.5	179.0	207.3	14500.0	14462.5	14587.5
1380.0	71.4	350.3	25.2	235.8	222.3	179.1	208.0	14500.0	14425.0	14675.0
1390.0	71.1	353.3	20.9	235.3	223.5	180.3	208.8	14500.0	14475.0	14587.5
1400.0	71.7	344.5	18.9	235.3	223.8	180.0	209.3	14500.0	14525.0	14512.5
1410.0	71.9	353.5	22.1	236.0	224.3	181.1	210.0	14425.0	14425.0	11937.5
1420.0	72.3	351.3	6.1	234.8	223.5	180.6	209.8	14312.5	14275.0	4550.0
1430.0	83.3	337.3	2.2	234.0	223.5	181.8	271.8	14050.0	13950.0	2704.1
1440.0	103.6	311.5	1.3	229.3	228.3	177.8	272.3	13200.0	13125.0	2054.7
1450.0	104.4	283.5	0.6	223.3	227.8	177.8	268.5	12025.0	12000.0	1654.7
1460.0	102.9	275.0	0.8	218.0	225.0	176.1	253.0	10925.0	10837.5	1460.8
1470.0	102.1	258.5	0.5	212.8	220.3	177.5	238.3	9861.3	9718.8	1367.2
1480.0	101.6	247.8	-0.0	207.5	213.8	177.5	239.5	8893.8	8825.0	1206.3
1490.0	100.9	246.3	-0.3	202.8	208.0	176.4	221.5	7962.5	7925.0	1075.0

RS-31 FLYWHEEL TEST — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:51:08 — FILE 01

CHANNEL	12	13	14	17	18	19	20	10	56	51
	M22	M23	M24	M4	M5	M6	M7	M1	M2	M3
TIME	FOP	AOP	GBOP	RRGRT	LRGRT	RFGRT	LFGRT	PH SPEED	LP SPEED	GR SPEED
SEC	PSIG	PSIG	PSIG	DEG F	DEG F	DEG F	DEG F	RPM	RPM	RPM
1500.0	102.9	247.8	0.0	198.0	202.9	176.0	222.3	7075.0	6968.6	1079.7
1510.0	102.9	242.5	-0.0	193.6	198.4	175.1	213.3	6237.5	6125.0	1012.5
1520.0	102.9	233.5	-0.4	189.5	194.1	173.6	206.8	5431.3	5437.5	860.9
1530.0	102.4	226.3	-0.2	185.5	190.5	172.3	203.6	4668.8	4709.4	762.5
1540.0	103.0	211.5	-0.0	182.0	187.4	171.0	200.8	3940.6	3921.9	792.2
1550.0	103.1	197.3	-0.3	178.6	184.4	169.6	195.5	3250.0	3328.1	628.1
1560.0	103.0	193.1	-0.4	175.8	181.3	168.3	191.4	2590.6	2665.6	532.8
1570.0	103.0	195.1	-0.8	172.9	177.0	167.0	187.5	1959.4	2073.4	384.4
1580.0	102.6	190.9	-0.7	169.6	174.1	165.8	185.8	1360.9	1396.9	341.3
1590.0	103.5	189.6	-1.0	165.8	169.4	164.5	182.8	792.2	832.8	134.4
1600.0	100.1	186.5	-1.0	164.1	167.3	163.1	182.3	245.3	300.0	76.6
1610.0	77.3	187.5	-0.7	162.3	164.9	161.3	177.0	103.1	165.6	46.9
1620.0	77.8	192.3	-0.3	161.1	165.5	160.8	175.6	90.6	173.4	-9.4
1630.0	78.1	187.8	-0.2	160.3	165.9	159.9	174.0	78.1	214.1	-71.9

RS-31 FLYWHEEL TEST — TEST 1 — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:26:19 — FILE 01

CHANNEL	52	53	54	55	56	57	58	59	62	15	10
	M9	M10	M26	M27	M28	M29	M31	M32	P56	P57	
TIME SEC	LFCAVT DEG F	AOT DEG F	RF GAP PICO F	LF GAP PICO F	RR GAP PICO F	LR GAP PICO F	LF VIB G	RR VIB G	RTAP PSIG	RTOP PSIG	TIME PULSE
0.0	67.8	73.0	-0.9	13.9	-2.5	-1.3	-0.0	-0.1	-5.18	0.05	-0.2
10.0	67.6	72.9	-0.8	14.0	-2.4	-1.1	-0.0	-0.1	-5.18	0.11	-0.3
20.0	69.0	73.8	-0.7	14.1	-2.1	-1.0	0.0	-0.0	-5.83	0.31	-0.2
30.0	68.4	91.3	-0.6	14.1	-1.9	-1.0	-0.0	-0.0	-5.39	-0.19	-0.2
40.0	65.3	96.6	-0.7	14.1	-2.1	-1.1	-0.0	-0.0	-4.58	0.09	-0.2
50.0	65.2	95.3	-0.6	14.2	-2.1	-1.0	-0.0	-0.0	-5.29	12.17	-0.2
60.0	68.3	92.5	-0.4	14.2	-2.0	-0.9	0.0	0.0	-4.96	15.00	-0.2
70.0	66.3	89.3	-0.5	14.2	-2.0	-1.0	-0.0	-0.0	-5.39	16.36	-0.2
80.0	68.3	86.9	-0.5	14.2	-2.0	-1.0	-0.0	-0.0	-13.22	18.09	-0.2
90.0	66.2	84.9	-0.8	14.2	-1.9	-1.0	0.0	0.0	-18.75	17.22	-0.2
100.0	65.6	83.7	-0.7	14.2	-1.8	-1.0	0.0	0.0	-17.75	16.52	-0.2
110.0	64.9	82.7	-0.9	14.2	-1.6	-1.1	-0.0	-0.0	-17.10	16.96	-0.2
120.0	68.2	82.7	-0.7	14.2	-1.6	-1.0	0.0	0.0	-15.32	16.69	-0.2
130.0	68.7	82.3	-0.6	14.2	-1.4	-1.0	-0.0	-0.0	-15.81	17.63	-0.2
140.0	68.2	82.6	-0.6	14.1	-1.4	-1.0	0.0	0.0	-14.46	17.48	-0.2
150.0	65.4	82.2	-0.9	14.1	-1.3	-1.1	-0.0	-0.0	-14.73	16.77	-0.2
160.0	65.8	82.5	-0.9	14.2	-1.3	-1.1	-0.0	-0.0	-14.08	17.09	5.8
170.0	66.7	82.2	-0.8	14.2	-1.3	-1.1	-0.0	-0.0	-14.62	17.38	14.0
180.0	68.2	82.5	-0.6	14.2	-1.2	-1.0	0.0	0.0	-14.35	17.29	37.3
190.0	67.6	82.4	-0.6	14.2	-1.1	-0.9	0.1	0.1	-14.03	16.35	97.0
200.0	66.9	82.2	-0.7	14.2	-0.9	-0.9	0.1	0.6	-14.70	16.72	161.6
210.0	66.1	82.4	-0.4	14.2	-0.7	-0.5	0.2	0.9	-13.65	16.13	227.2
220.0	66.5	82.6	-0.0	14.2	-0.4	-0.3	0.1	0.1	-15.11	16.05	294.0
230.0	65.1	82.6	0.2	14.2	-0.0	0.0	0.0	0.0	-13.60	15.99	363.0
240.0	64.8	82.8	0.6	14.2	0.3	0.4	0.2	0.3	-14.41	16.19	432.4
250.0	64.8	83.0	1.1	14.3	0.9	1.0	0.0	0.0	-14.08	16.25	502.0
260.0	65.9	83.3	2.0	14.3	1.6	1.6	0.0	0.0	-13.33	16.11	571.9
270.0	68.8	83.5	3.1	14.4	2.3	2.7	0.0	0.0	-14.05	16.30	639.1
280.0	65.2	83.7	3.7	14.4	3.3	3.4	0.0	-0.0	-14.08	16.45	708.1
290.0	65.7	83.8	4.9	14.4	4.3	4.4	0.0	-0.0	-13.06	16.66	776.9

RS-31 FLYWHEEL TEST — TEST 2 — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:31:09 — FILE 01

CHANNEL	52	53	54	55	56	57	58	59	62	15	10
	M9	M10	M26	M27	M28	M29	M31	M32	M56	M57	
TIME	LFCAVT	AOT	RF GAP	LF GAP	RR GAP	LR GAP	LF VIB	RR VIB	GTAP	LTOP	LFT
SEC	DEG F	DEG F	PICO F	PICO F	PICO F	PICO F	G	G	PSIG	PSIG	PULSE
300.0	66.9	83.6	6.2	14.5	5.4	5.6	0.0	0.0	-14.08	16.22	880.0
310.0	69.1	84.0	7.8	14.5	6.7	7.0	0.1	0.0	-13.[illegible]	16.77	905.0
320.0	67.9	84.4	9.4	14.6	8.1	8.5	0.0	0.0	-13.65	15.41	967.5
330.0	68.6	84.6	11.2	14.6	9.8	10.3	0.0	0.1	-13.16	15.59	1021.3
340.0	68.0	84.8	13.0	14.6	11.5	12.0	0.0	0.1	-13.22	15.78	1085.0
350.0	66.2	84.9	14.6	14.7	13.2	13.8	0.0	0.0	-13.16	15.00	1132.5
360.0	66.7	85.4	16.3	14.7	14.6	15.3	0.0	0.1	-13.70	14.59	1166.3
370.0	65.0	85.8	17.7	14.7	15.9	16.6	0.0	0.0	-12.95	15.[illegible]	1197.5
380.0	66.6	86.3	19.5	14.7	17.4	18.3	0.0	0.1	-13.06	15.48	1226.3
390.0	65.5	87.2	20.8	14.7	18.8	19.8	0.1	0.0	-13.97	15.63	1255.0
400.0	64.8	88.1	22.3	14.8	20.2	21.2	0.1	0.0	-13.65	14.49	1276.3
410.0	67.6	88.7	24.0	14.8	21.5	22.6	0.2	0.1	-13.16	14.55	1296.3
420.0	68.8	89.8	25.5	14.8	22.8	24.0	0.3	0.1	-13.49	16.75	1316.3
430.0	68.5	90.8	26.9	14.9	23.9	25.3	0.3	0.1	-14.03	15.73	1331.3
440.0	66.1	92.3	26.5	14.9	23.8	25.2	0.3	0.0	-13.76	14.52	1320.0
450.0	67.1	93.5	25.9	14.9	23.3	24.6	0.4	0.1	-13.92	15.30	1320.0
460.0	67.8	94.6	25.8	15.0	23.0	24.4	0.3	0.0	-14.35	14.48	1315.0
470.0	68.9	96.4	26.4	15.0	23.5	25.0	0.3	0.1	-13.[illegible]	13.53	1320.0
480.0	69.0	98.1	27.3	15.1	24.3	25.8	0.3	0.1	-14.51	13.05	1320.0
490.0	67.5	99.7	28.2	15.1	25.4	26.9	0.3	-0.0	-14.41	13.59	1303.8
500.0	67.4	101.3	28.8	15.1	25.9	27.5	0.3	-0.0	-14.41	14.09	1300.0
510.0	67.4	103.0	28.5	15.1	25.7	27.3	0.2	0.0	-14.78	13.[illegible]	1307.5
520.0	70.5	104.6	28.7	15.1	25.5	27.2	0.3	0.0	-14.89	13.75	1303.8
530.0	70.4	106.6	29.3	15.1	26.1	27.9	0.3	0.1	-13.65	14.56	1301.0
540.0	68.0	108.2	30.3	15.2	27.2	29.1	0.2	0.1	-14.62	14.70	1303.8
550.0	68.7	110.0	32.0	15.2	28.7	30.7	0.3	0.0	-14.[illegible]	13.00	1300.0
560.0	70.6	111.4	33.8	15.2	30.0	32.3	0.3	0.0	-14.40	13.[illegible]	1301.3
570.0	70.0	113.3	35.1	15.2	31.1	33.7	0.4	0.1	-14.70	13.11	1306.3
580.0	68.5	115.0	36.6	15.2	32.6	35.3	0.3	0.0	-15.00	13.[illegible]	1300.0
590.0	69.0	116.6	38.7	15.3	34.5	37.4	0.4	0.0	-15.21	12.[illegible]	1301.3

RS-31 FLYWHEEL TEST — 10:FW 3 — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:36:01 — FILE 01

CHANNEL	52	53	54	55	56	57	58	59	62	15	10
	M9	M10	M26	M27	M28	M29	M31	M32	M56	M57	
TIME	LFCAVT	AOT	RF GAP	LF GAP	RR GAP	LR GAP	LF VIB	RR VIB	RTAP	RTOP	TIME
SEC	DEG F	DEG F	PICO F	PICO F	PICO F	PICO F	G	G	PSIG	PSIG	PULSE
600.0	69.0	118.2	40.0	15.3	35.6	38.8	0.4	-0.0	-14.14	13.41	1406.3
610.0	72.4	119.5	40.7	15.3	35.9	39.3	0.4	0.0	-14.95	12.47	1408.8
620.0	72.6	121.4	39.3	15.3	34.5	38.1	0.2	0.2	-15.32	13.05	1436.3
630.0	71.4	123.0	37.6	15.3	33.2	36.7	0.3	0.2	-14.19	11.31	1423.8
640.0	72.0	124.3	36.2	15.3	31.9	35.3	0.2	0.1	-15.11	13.66	1411.3
650.0	71.9	126.1	34.7	15.4	30.8	34.1	0.2	0.1	-14.51	13.20	1400.0
660.0	73.3	127.8	33.7	15.4	29.6	33.0	0.2	0.2	-14.78	11.29	1398.8
670.0	70.9	129.1	32.3	15.4	28.7	32.0	0.2	0.0	-14.95	11.72	1376.3
680.0	74.0	131.1	31.5	15.4	27.7	31.1	0.2	0.1	-14.68	11.59	1363.8
690.0	73.7	132.6	30.4	15.4	26.8	30.1	0.2	0.1	-15.11	12.34	1353.8
700.0	72.8	134.0	29.4	15.3	25.8	29.2	0.2	0.1	-13.11	11.14	1343.8
710.0	71.1	135.3	28.2	15.3	25.0	28.3	0.1	0.1	-15.32	10.95	1332.5
720.0	72.0	137.0	27.4	15.4	24.2	27.4	0.0	-0.0	-15.75	12.20	1321.3
730.0	73.5	138.1	26.7	15.4	23.4	26.7	0.0	0.0	-15.32	11.42	1311.3
740.0	74.8	138.9	26.2	15.4	22.8	26.1	0.1	0.0	-15.16	11.42	1301.3
750.0	76.1	140.3	25.4	15.4	22.1	25.5	0.1	0.0	-14.57	11.66	1291.3
760.0	74.8	141.2	24.5	15.4	21.5	24.8	0.1	0.0	-14.51	11.49	1281.3
770.0	76.5	141.9	24.0	15.4	20.9	24.3	0.1	0.1	-14.73	12.16	1271.3
780.0	75.0	143.3	23.2	15.4	20.2	23.6	0.0	-0.0	-14.95	11.63	1262.5
790.0	75.6	144.1	22.6	15.4	19.7	23.0	0.0	0.0	-15.05	9.72	1252.5
800.0	73.4	144.7	22.0	15.5	19.1	22.5	0.0	-0.0	-15.16	10.59	1242.5
810.0	75.2	145.6	21.5	15.4	18.6	22.0	0.1	-0.0	-15.11	10.03	1233.8
820.0	75.6	146.3	20.9	15.4	18.1	21.5	0.1	-0.0	-14.51	10.23	1225.0
830.0	76.6	147.0	20.5	15.4	17.6	21.1	0.1	0.0	-15.32	8.59	1215.0
840.0	76.8	147.4	20.0	15.4	17.2	20.6	0.0	0.0	-15.38	10.28	1206.3
850.0	78.1	148.1	19.7	15.5	16.7	20.3	0.1	0.0	-15.54	9.88	1197.5
860.0	76.1	148.6	19.0	15.5	16.2	19.7	0.0	-0.0	-14.73	10.16	1188.7
870.0	78.1	148.4	18.7	15.5	15.8	19.3	0.1	0.0	-14.41	9.69	1180.0
880.0	78.8	148.6	18.2	15.4	15.3	18.9	0.1	0.0	-14.95	9.79	1171.3
890.0	77.9	148.8	17.7	15.4	14.8	18.5	0.1	0.0	-14.73	9.32	1162.5

RS-31 FLYWHEEL TEST

DATA INTERVAL IS 10 SECONDS

	53	54	55	56	57	58	59	62	15	10
	M10	M26	M27	M28	M29	M31	M32	M56	M57	
	AOT	RF GAP	LF GAP	RR GAP	LR GAP	LF VIB	PR VIB	RTAP	RTOP	TPT
	DEG F	PICO F	PICO F	PICO F	PICO F	G	G	PSIG	PSIG	PDEG
[illegible]	76.5	148.8	17.3	15.4	14.4	18.1	0.0	0.1	-15.16	9.69	[illegible]
910.0	75.9	148.5	16.8	15.4	14.1	17.7	0.0	0.0	-15.16	10.05	1105.0
920.0	79.7	148.4	16.8	15.4	13.8	17.5	0.0	0.1	-15.11	11.36	1136.3
930.0	76.8	148.2	16.2	15.4	13.5	17.2	0.1	0.0	-15.54	8.50	1122.9
940.0	77.4	148.0	15.7	15.5	13.2	16.9	0.0	0.0	-15.70	7.34	1120.0
950.0	79.2	147.9	15.7	15.5	12.9	16.6	0.0	0.0	-15.86	9.77	1111.3
960.0	77.4	147.3	15.2	15.5	12.5	16.2	0.0	0.0	-15.75	8.81	1103.1
970.0	78.2	147.0	14.8	15.5	12.2	15.9	-0.0	-0.0	-15.70	8.78	1093.0
980.0	80.4	146.5	14.7	15.5	12.0	15.7	0.0	0.0	-15.59	8.73	1087.5
990.0	81.1	146.3	14.8	15.5	12.0	15.5	0.0	0.1	-15.96	9.41	1085.0
1000.0	79.9	146.1	15.4	15.5	12.5	15.5	0.0	0.1	-15.75	8.73	1102.5
1010.0	78.4	145.6	16.5	15.6	13.6	16.5	-0.0	0.0	-15.65	8.17	1132.5
1020.0	82.1	145.6	18.8	15.6	15.4	18.7	0.1	0.1	-14.89	9.13	1173.8
1030.0	80.5	145.3	21.3	15.6	17.8	21.3	0.1	0.0	-14.95	9.02	1230.0
1040.0	83.0	145.0	24.7	15.6	20.6	24.6	0.2	0.0	-15.05	9.63	1285.0
1050.0	80.0	145.2	27.8	15.6	23.4	27.9	0.1	0.0	-14.78	10.34	1332.0
1060.0	81.4	145.1	31.5	15.6	26.4	31.5	0.3	0.2	-14.24	9.11	1366.3
1070.0	82.2	144.9	34.4	15.5	28.9	34.6	0.2	0.0	-14.73	9.78	1389.0
1080.0	80.3	145.1	35.8	15.5	30.0	36.0	0.2	0.1	-15.86	9.30	1401.5
1090.0	81.8	145.4	37.0	15.5	31.0	37.3	0.1	0.0	-15.59	9.66	1409.5
1100.0	84.1	145.3	38.6	15.5	32.1	38.7	0.1	0.1	-14.64	8.88	1420.5
1110.0	81.5	145.6	39.7	15.5	33.1	40.0	0.1	0.1	-15.08	9.25	1426.5
1120.0	82.4	146.3	40.2	15.5	33.5	40.5	0.1	0.0	-14.78	9.61	1426.3
1130.0	85.2	146.6	40.5	15.5	33.5	40.7	0.2	0.2	-14.62	9.06	1426.[illegible]
1140.0	82.1	146.6	40.3	15.5	33.5	40.7	0.1	0.1	-15.65	8.22	1427.[illegible]
1150.0	83.5	147.5	40.4	15.5	33.4	40.6	0.1	0.0	-14.62	9.16	1427.[illegible]
1160.0	85.1	148.1	40.4	15.4	33.3	40.7	0.2	0.2	-15.32	8.30	1427.5
1170.0	83.8	148.8	40.2	15.4	33.2	40.5	0.1	0.0	-15.21	9.38	1[illegible]
1180.0	84.0	149.2	40.3	15.4	33.2	40.6	0.2	0.2	-15.46	8.72	1426.[illegible]
1190.0	85.6	149.8	40.3	15.4	33.1	40.5	0.1	0.1	-15.00	9.17	1427.[illegible]

RS-31 FLYWHEEL TEST

DATA INTERVAL IS 10 SECONDS

11/26/79 17:46:09

CHANNEL	52	53	54	55	56	57	58	59	62	15	10
	M9	M10	M26	M27	M28	D29	M31	M32	D56	D57	
TIME	LFCAVT	AOT	RF GAP	LF GAP	RR GAP	LR GAP	LF VIB	RR VIB	RTAP	PTOP	TTT
SEC	DEG F	DEG F	PICO F	PICO F	PICO F	PICO F	G	G	PSIG	PSIG	PULSE
1200.0	85.2	150.8	40.1	15.4	33.1	40.4	0.1	0.0	-15.86	8.38	1000.3
1210.0	88.2	151.3	40.3	15.4	32.9	40.4	0.2	0.2	-14.51	9.63	1001.0
1220.0	87.8	151.8	40.3	15.4	32.9	40.4	0.1	0.1	-15.48	8.69	1000.3
1230.0	87.8	152.4	40.6	15.5	33.0	40.5	0.1	0.1	-15.21	8.80	1000.3
1240.0	86.7	153.1	40.5	15.5	33.0	40.7	0.1	0.2	-14.46	8.38	1997.5
1250.0	86.4	153.9	40.6	15.5	33.0	40.7	0.1	0.0	-15.65	8.47	1001.8
1260.0	88.9	154.4	40.9	15.5	33.0	40.8	0.2	0.2	-15.59	8.44	1001.8
1270.0	86.3	154.6	40.6	15.5	32.8	40.6	0.1	0.0	-14.51	7.36	1001.8
1280.0	88.0	155.1	40.6	15.4	32.7	40.5	0.1	0.2	-15.48	7.70	1997.5
1290.0	87.0	155.1	40.3	15.4	32.5	40.3	0.0	0.0	-15.54	8.02	1997.5
1300.0	88.7	155.3	40.3	15.4	32.4	40.2	0.1	0.1	-15.11	7.27	1997.5
1310.0	89.6	155.4	40.3	15.4	32.3	40.2	0.1	0.2	-15.38	7.93	1000.3
1320.0	92.2	155.8	40.7	15.3	32.4	40.4	0.2	0.2	-15.70	8.38	1997.5
1330.0	92.7	155.6	40.8	15.3	32.5	40.5	0.1	0.1	-14.95	8.19	1998.0
1340.0	90.2	155.8	40.6	15.3	32.5	40.5	0.1	0.1	-15.21	8.51	1998.0
1350.0	91.7	156.0	40.6	15.3	32.3	40.4	0.1	0.2	-15.43	8.38	1998.0
1360.0	92.1	156.2	40.6	15.2	32.3	40.4	0.1	0.2	-15.21	8.58	1998.0
1370.0	93.8	156.4	40.6	15.2	32.2	40.4	0.2	0.2	-16.03	8.80	1998.0
1380.0	91.5	156.4	40.4	15.2	32.2	40.3	0.1	0.1	-14.94	8.72	1998.0
1390.0	94.2	156.8	40.4	15.2	32.1	40.2	0.1	0.1	-15.16	7.70	1998.0
1400.0	96.2	157.1	40.5	15.2	32.0	40.2	0.2	0.1	-14.89	7.05	1998.0
1410.0	94.5	157.5	39.3	15.2	31.2	38.9	0.1	0.0	-14.63	8.06	1997.5
1420.0	94.9	157.9	37.8	15.2	29.9	37.3	0.1	-0.0	-15.65	7.52	1001.5
1430.0	94.0	158.1	34.5	15.2	27.3	33.8	0.0	-0.0	7.85	6.30	1001.0
1440.0	95.7	158.4	26.5	15.2	20.5	25.3	0.3	0.0	88.07	23.02	1998.0
1450.0	97.1	158.1	19.2	15.2	14.2	17.9	0.2	0.0	89.30	19.56	1998.5
1460.0	97.6	158.6	14.5	15.2	10.0	13.3	0.2	0.0	91.52	18.36	1998.5
1470.0	96.1	158.6	10.9	15.2	7.1	10.1	0.1	-0.0	91.06	19.05	1998.1
1480.0	97.9	159.0	8.8	15.2	5.0	7.9	0.1	-0.0	90.20	20.11	1998.5
1490.0	99.0	158.8	7.2	15.2	3.4	6.4	0.1	0.0	90.73	20.53	1998.5

RS-31 FLYWHEEL TEST

DATA INTERVAL IS 10 SECONDS

11/26/79 17:51:00

CHANNEL	52	53	54	55	56	57	58	59	62	15	16
	M9	M10	M26	M27	M28	M29	M31	M32	M56	M57	
TIME	LFCAVT	AOT	RF GAP	LF GAP	RR GAP	LR GAP	LF VIB	RR VIB	RTAP	LTOP	LTSP
SEC	DEG F	DEG F	PICO F	PICO F	PICO F	PICO F	G	G	PSIG	PSIG	PULSE
1500.0	97.3	159.2	5.6	15.2	2.2	5.2	0.1	-0.0	79.66	20.72	707.5
1510.0	98.1	159.0	4.6	15.2	1.2	4.2	0.1	0.0	79.76	20.98	694.8
1520.0	101.2	159.2	4.0	15.2	0.4	3.4	0.1	0.0	79.66	21.61	583.1
1530.0	102.0	159.0	3.3	15.2	-0.3	2.8	0.1	0.1	79.98	23.81	4[illegible].0
1540.0	99.1	158.4	2.4	15.1	-0.7	1.5	0.0	-0.0	79.22	22.66	3[illegible].1
1550.0	102.2	158.1	2.2	15.1	-1.0	1.9	0.0	-0.0	79.44	24.56	3[illegible].0
1560.0	103.1	157.7	1.9	15.1	-1.2	1.7	0.1	-0.1	79.55	25.22	2[illegible].1
1570.0	104.1	157.1	1.7	15.1	-1.0	1.9	0.1	0.0	78.90	25.61	1[illegible].9
1580.0	101.0	156.5	1.4	15.1	-0.8	1.9	0.1	-0.0	79.76	25.78	1[illegible].1
1590.0	101.7	155.8	1.4	15.1	-0.6	1.9	0.0	-0.0	77.82	26.78	7[illegible].2
1600.0	102.0	155.3	1.2	15.1	-0.3	2.0	0.0	-0.1	79.66	26.75	3[illegible].1
1610.0	102.9	155.0	1.2	15.1	-0.3	2.0	-0.1	-0.0	-6.69	12.72	10.3
1620.0	104.7	154.4	1.5	15.1	-0.3	2.1	0.0	0.0	-7.55	12.39	7.1
1630.0	106.2	153.2	1.5	15.1	-0.2	2.1	0.0	0.0	-7.34	14.14	7.8

RS-31 FLYWHEEL TEST

DATA INTERVAL IS 10 SECONDS

11/26/79 17:26:1?

CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
0.0	6.3	1.6	78.9	68.2
10.0	6.3	1.6	79.3	67.5
20.0	7.8	1.6	80.2	71.6
30.0	6.3	3.1	80.0	90.8
40.0	7.8	1.6	75.5	97.0
50.0	6.3	3.1	76.8	92.1
60.0	6.3	3.1	80.1	88.9
70.0	7.8	1.6	76.0	88.5
80.0	6.3	3.1	78.9	86.2
90.0	6.3	3.1	77.7	82.1
100.0	7.8	4.7	76.2	80.4
110.0	6.3	3.1	74.6	80.5
120.0	7.8	1.6	78.8	78.3
130.0	7.8	3.1	78.3	79.2
140.0	6.3	4.7	78.2	78.7
150.0	7.8	3.1	73.6	80.7
160.0	-34.4	1.6	95.7	74.7
170.0	223.4	448.4	75.9	81.0
180.0	496.9	496.9	77.4	79.3
190.0	1001.6	993.8	76.3	77.6
200.0	1606.3	1642.2	74.3	81.4
210.0	2307.8	2303.1	74.6	78.9
220.0	2978.1	2968.8	73.5	80.9
230.0	3678.1	3665.6	73.3	80.3
240.0	4362.5	4356.3	72.6	80.4
250.0	5068.8	5065.6	71.6	81.8
260.0	5762.5	5756.3	71.6	82.4
270.0	6418.8	6412.5	77.4	80.3
280.0	7125.0	7118.8	70.9	83.4
290.0	7806.3	7806.3	71.5	82.6

RS-31 FLYWHEEL TEST TAPE 351

DATA INTERVAL IS 10 SECONDS 11/26/79 17:31:01 FILE 01

CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
300.0	8437.5	8431.3	73.4	82.1
310.0	9087.5	9081.3	75.4	82.6
320.0	9712.5	9712.5	76.1	80.0
330.0	10350.0	10350.0	72.4	79.4
340.0	10887.5	10887.5	76.3	80.4
350.0	11362.5	11350.0	72.4	81.4
360.0	11687.5	11687.5	76.4	83.0
370.0	12000.0	12000.0	72.4	84.6
380.0	12300.0	12287.5	76.8	83.5
390.0	12575.0	12575.0	72.3	87.4
400.0	12800.0	12787.5	73.4	87.1
410.0	13000.0	12987.5	77.4	87.1
420.0	13187.5	13175.0	77.9	89.2
430.0	13337.5	13325.0	80.0	91.1
440.0	13312.5	13300.0	74.3	93.3
450.0	13225.0	13212.5	75.3	93.4
460.0	13175.0	13162.5	77.7	94.4
470.0	13225.0	13225.0	81.1	94.1
480.0	13337.5	13325.0	82.1	94.9
490.0	13462.5	13462.5	78.2	98.6
500.0	13525.0	13512.5	79.4	100.4
510.0	13487.5	13487.5	78.3	103.4
520.0	13462.5	13450.0	86.9	102.8
530.0	13537.5	13525.0	85.1	104.6
540.0	13675.0	13662.5	82.1	107.6
550.0	13837.5	13825.0	82.6	111.1
560.0	13975.0	13975.0	87.4	112.6
570.0	14087.5	14087.5	88.6	110.9
580.0	14237.5	14225.0	86.1	114.3
590.0	14400.0	14387.5	86.4	117.5

RS-31 FLYWHEEL TEST — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:36:0 — FILE 01

CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
600.0	14487.5	14475.0	88.3	117.6
610.0	14512.5	14500.0	92.3	119.8
620.0	14387.5	14387.5	95.6	119.8
630.0	14262.5	14275.0	96.1	121.3
640.0	14137.5	14162.5	96.7	124.6
650.0	14025.0	14050.0	96.1	126.1
660.0	13900.0	13937.5	99.9	125.8
670.0	13787.5	13825.0	97.0	127.1
680.0	13675.0	13725.0	102.0	128.1
690.0	13562.5	13612.5	103.6	131.1
700.0	13450.0	13512.5	103.8	132.3
710.0	13337.5	13425.0	103.1	134.5
720.0	13237.5	13312.5	102.8	137.3
730.0	13137.5	13212.5	105.1	138.3
740.0	13037.5	13125.0	109.9	139.0
750.0	12937.5	13025.0	111.1	137.9
760.0	12837.5	12937.5	110.3	141.3
770.0	12737.5	12837.5	112.5	143.8
780.0	12637.5	12750.0	110.6	143.4
790.0	12537.5	12662.5	111.5	144.1
800.0	12450.0	12575.0	114.0	144.5
810.0	12350.0	12487.5	114.5	145.8
820.0	12262.5	12400.0	115.4	146.0
830.0	12175.0	12325.0	120.1	145.1
840.0	12075.0	12237.5	118.0	147.0
850.0	11987.5	12150.0	122.5	146.6
860.0	11900.0	12062.5	119.9	148.8
870.0	11812.5	11987.5	123.1	149.6
880.0	11725.0	11912.5	124.1	149.5
890.0	11637.5	11825.0	125.4	146.3

RS-31 FLYWHEEL TEST

DATA INTERVAL IS 10 SECONDS

11/26/79 17:41:00

CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
900.0	11550.0	11750.0	124.9	147.5
910.0	11462.5	11662.5	124.1	147.0
920.0	11387.5	11587.5	128.5	147.3
930.0	11300.0	11512.5	128.1	147.0
940.0	11212.5	11425.0	127.6	147.9
950.0	11137.5	11350.0	130.5	145.4
960.0	11050.0	11275.0	129.1	146.6
970.0	10962.5	11200.0	127.9	146.1
980.0	10887.5	11125.0	130.1	146.0
990.0	10875.0	11050.0	134.4	144.4
1000.0	11050.0	11037.5	135.5	145.4
1010.0	11362.5	11350.0	131.3	146.4
1020.0	11812.5	11812.5	136.1	144.9
1030.0	12337.5	12325.0	132.6	145.1
1040.0	12875.0	12862.5	136.6	145.3
1050.0	13325.0	13312.5	134.0	145.8
1060.0	13725.0	13712.5	137.1	143.4
1070.0	14025.0	14012.5	137.0	144.0
1080.0	14150.0	14150.0	136.6	143.1
1090.0	14250.0	14237.5	135.3	146.5
1100.0	14362.5	14350.0	139.5	145.6
1110.0	14450.0	14450.0	137.6	144.1
1120.0	14487.5	14487.5	138.4	147.1
1130.0	14487.5	14487.5	142.3	145.9
1140.0	14500.0	14487.5	140.5	145.9
1150.0	14500.0	14487.5	140.4	147.6
1160.0	14500.0	14500.0	145.0	146.9
1170.0	14500.0	14500.0	141.4	148.9
1180.0	14500.0	14500.0	146.3	146.4
1190.0	14500.0	14487.5	145.4	149.0

RS-31 FLYWHEEL TEST — TAPE 351

DATA INTERVAL IS 10 SECONDS — 11/26/79 17:46:08 — FILE 01

CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
1200.0	14487.5	14475.0	144.5	150.4
1210.0	14475.0	14475.0	149.8	149.6
1220.0	14487.5	14475.0	147.9	151.4
1230.0	14487.5	14487.5	149.5	152.9
1240.0	14500.0	14487.5	150.6	152.4
1250.0	14500.0	14500.0	149.1	153.6
1260.0	14512.5	14500.0	153.8	152.9
1270.0	14500.0	14500.0	151.8	154.0
1280.0	14500.0	14487.5	155.6	153.0
1290.0	14487.5	14487.5	153.4	153.4
1300.0	14487.5	14487.5	156.4	154.5
1310.0	14487.5	14487.5	157.9	153.5
1320.0	14500.0	14500.0	159.5	153.6
1330.0	14525.0	14512.5	159.6	155.1
1340.0	14525.0	14512.5	158.8	155.3
1350.0	14525.0	14512.5	162.1	153.8
1360.0	14525.0	14512.5	163.1	154.1
1370.0	14525.0	14512.5	164.0	153.8
1380.0	14525.0	14512.5	164.0	155.0
1390.0	14525.0	14512.5	162.8	156.6
1400.0	14512.5	14512.5	166.6	156.5
1410.0	14437.5	14425.0	164.8	156.4
1420.0	14325.0	14312.5	164.5	158.5
1430.0	14062.5	14037.5	165.6	158.4
1440.0	13175.0	13125.0	166.3	158.4
1450.0	12012.5	11925.0	169.6	157.9
1460.0	11387.5	10825.0	172.9	156.8
1470.0	10125.0	9781.3	168.4	159.0
1480.0	9268.8	8806.3	169.5	158.6
1490.0	8000.0	7887.5	171.3	159.5

RS-31 FLYWHEEL TEST

DATA INTERVAL IS 10 SECONDS

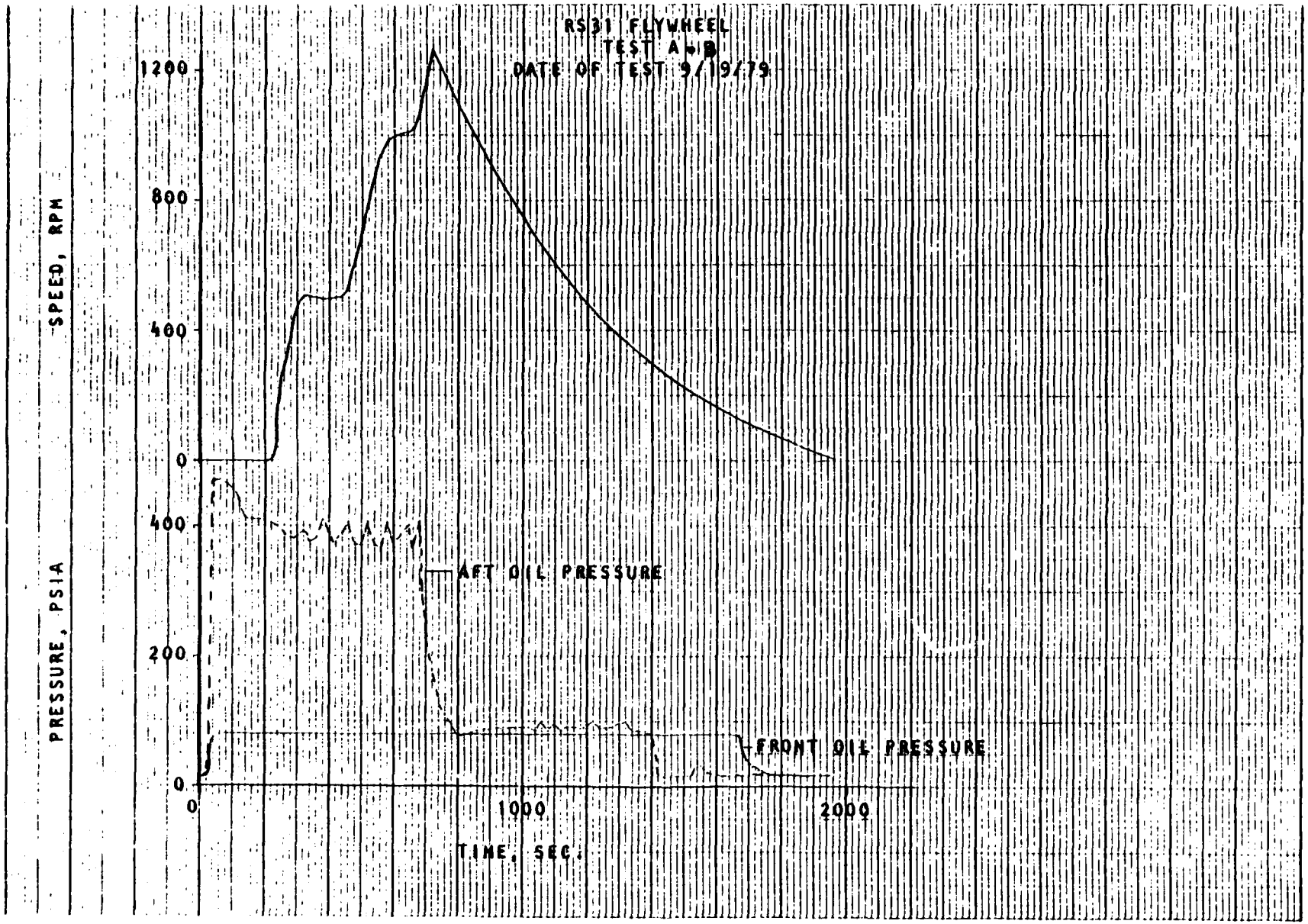
11/26/79 17:51:09

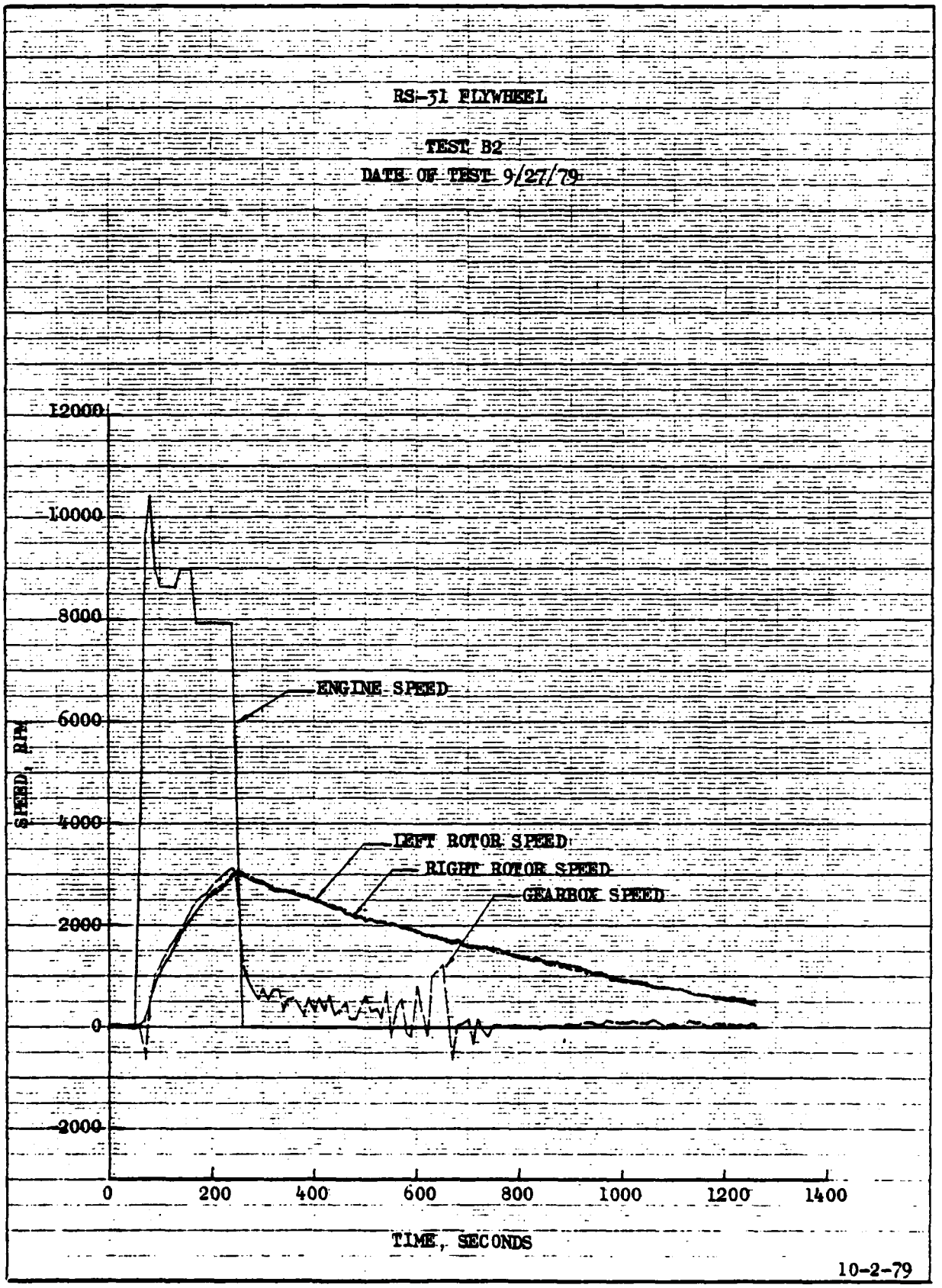
CHANNEL	63	64	65	68
	M-1	M-2	M70	M71
TIME SEC	RH SPEED RPM	LH SPEED RPM	RESVOT DEG F	INLOT DEG F
1500.0	7206.3	7018.8	171.9	158.0
1510.0	7207.5	6193.8	173.5	158.6
1520.0	6137.5	5406.3	176.1	157.0
1530.0	4903.1	4612.5	176.5	156.5
1540.0	4393.8	3950.0	176.9	156.6
1550.0	3628.1	3506.3	173.8	157.8
1560.0	2834.4	3243.8	174.5	156.6
1570.0	2339.4	2646.9	177.0	156.4
1580.0	3190.6	1843.8	174.4	155.1
1590.0	840.6	862.5	173.8	155.6
1600.0	470.3	314.1	173.4	155.3
1610.0	6.3	439.1	173.4	155.3
1620.0	9.4	410.9	177.1	152.5
1630.0	335.9	167.2	175.9	154.0

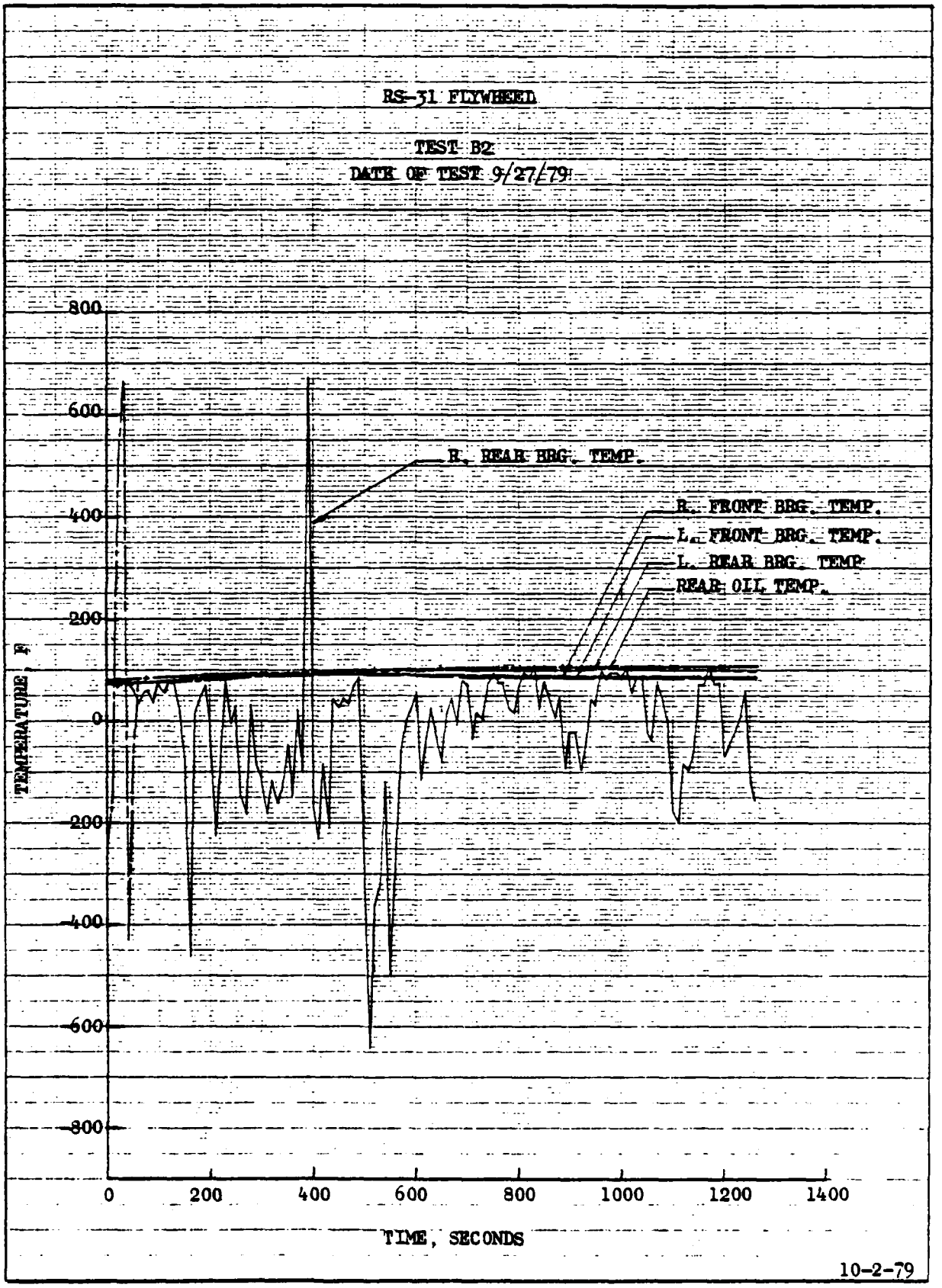
APPENDIX B

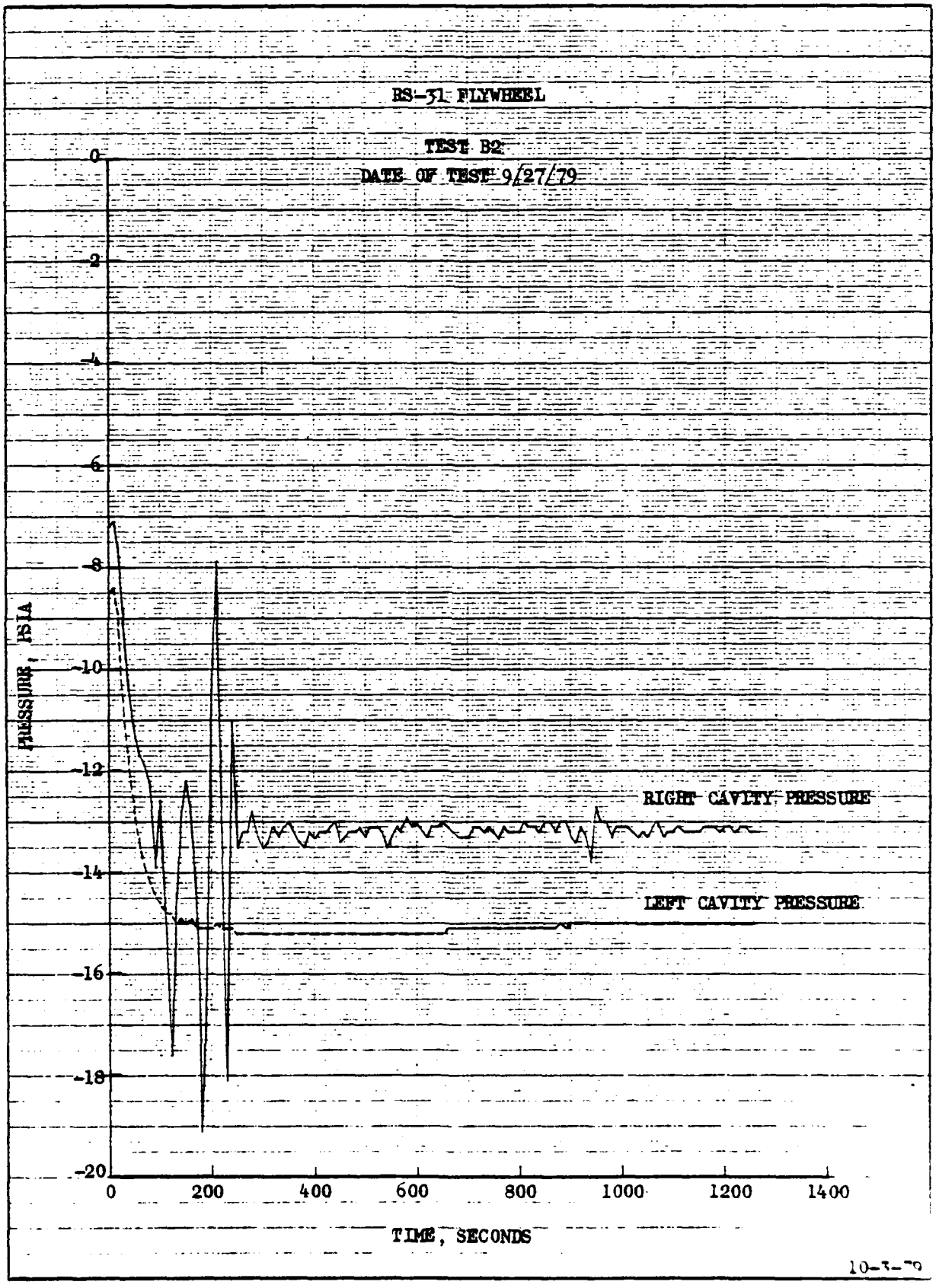
TYPICAL DATA RESULTS

PLOTTED DATA FOR 9 TESTS


RS31 FLYWHEEL
TEST A-1B
DATE OF TEST 9/19/79
SPEED, RPM
PRESSURE, PSIA
1200
800
400
0
400
200
0
AFT OIL PRESSURE
FRONT OIL PRESSURE
0
1000
2000
TIME, SEC.

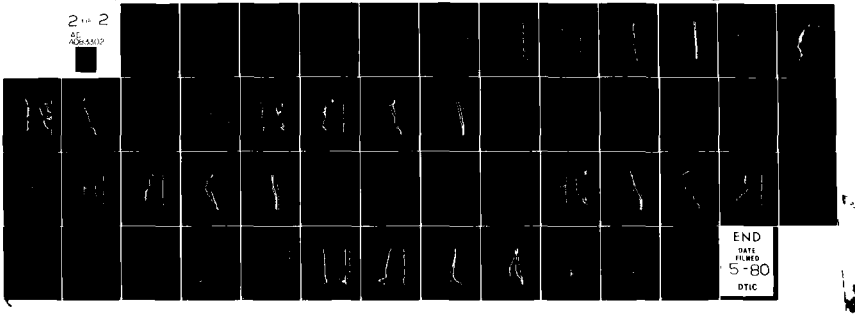

RS-31 FLYWHEEL
TEST B2
DATE OF TEST 9/27/79
12000
10000
8000
6000
4000
2000
0
2000
SPEED, RPM
ENGINE SPEED
LEFT ROTOR SPEED
RIGHT ROTOR SPEED
GEARBOX SPEED
0
200
400
600
800
1000
1200
1400
TIME, SECONDS
10-2-79


RS-31 FLYWHEEL
TEST B2
DATE OF TEST 9/27/79
800
600
400
200
0
-200
-400
-600
-800
TEMPERATURE, F
R. REAR BRG. TEMP.
R. FRONT BRG. TEMP.
L. FRONT BRG. TEMP.
L. REAR BRG. TEMP.
REAR OIL TEMP.
0
200
400
600
800
1000
1200
1400
TIME, SECONDS
10-2-79

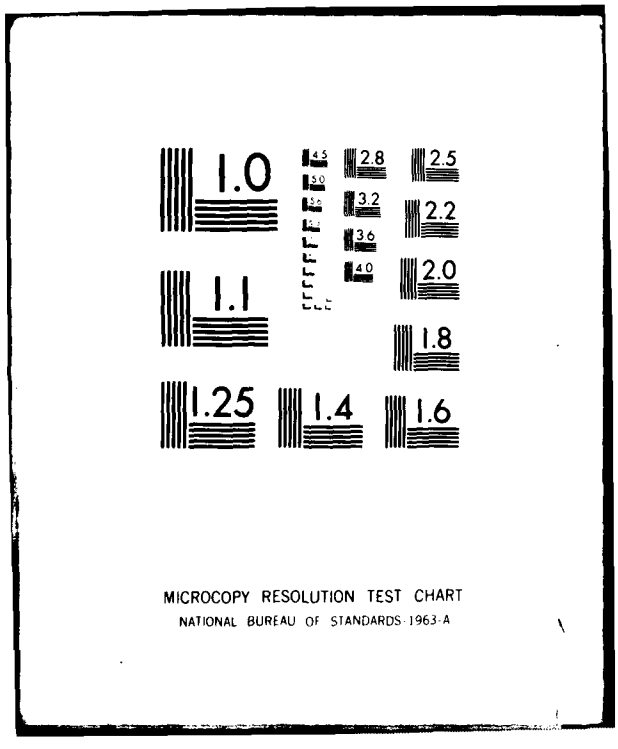

RS-31 FLYWHEEL
TEST B2
DATE OF TEST 9/27/79
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
PRESSURE, PSIA
RIGHT CAVITY PRESSURE
LEFT CAVITY PRESSURE
0
200
400
600
800
1000
1200
1400
TIME, SECONDS

AD-A083 302 ROCKWELL INTERNATIONAL CANOGA PARK CA ROCKETDYNE DIV F/G 10/3
HIGH ENERGY STORAGE FLYWHEEL TEST PROGRAM.(U)
JAN 80 D R HODSON DAAG53-78-C-0278
UNCLASSIFIED RI/RD78-207-1 NL

2 OF 2
AD-A083302



END
DATE FILMED
5-80
DTIC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1.1
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1.4
1.6
1.8
2.0
2.2
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3.6
4.0
4.5
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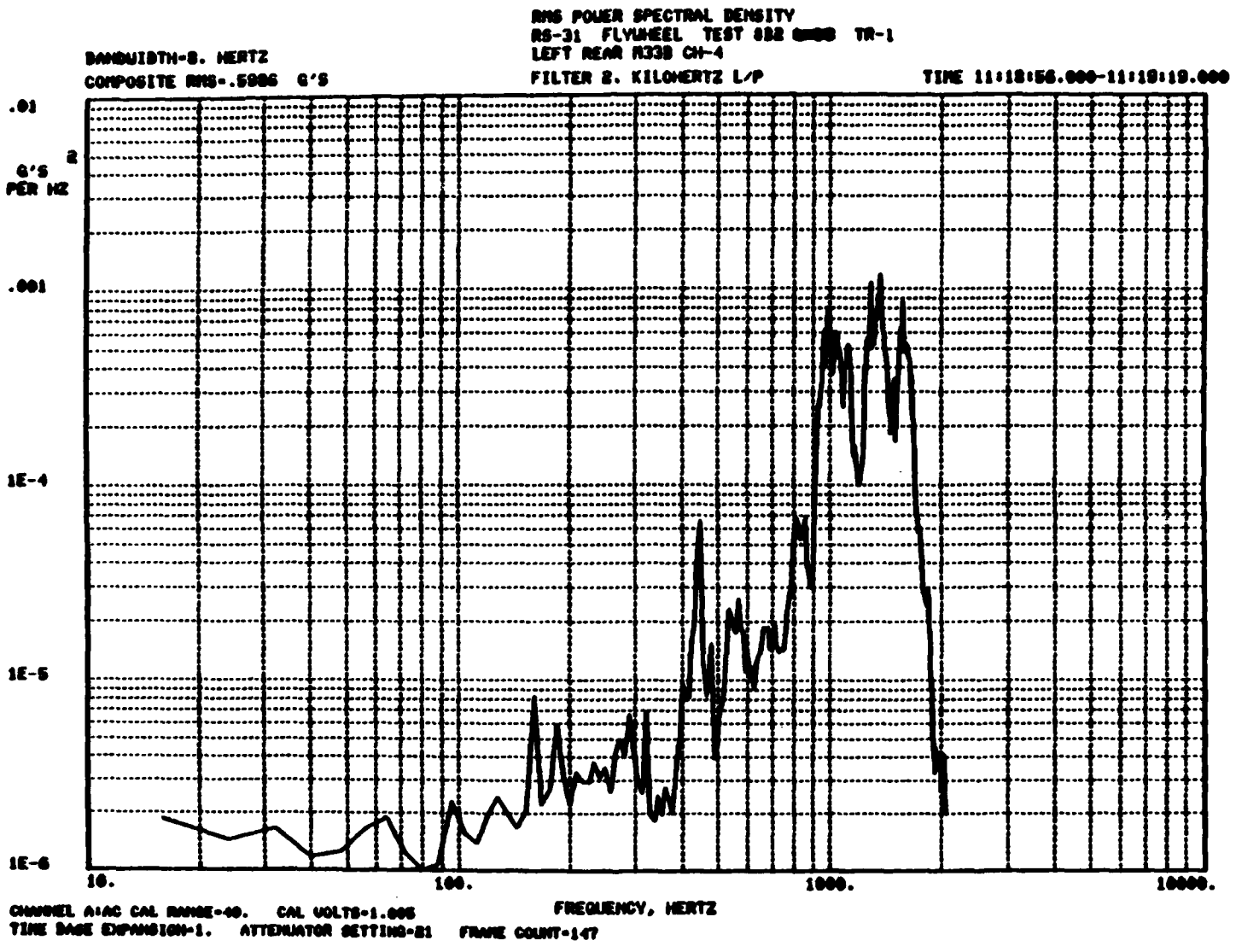
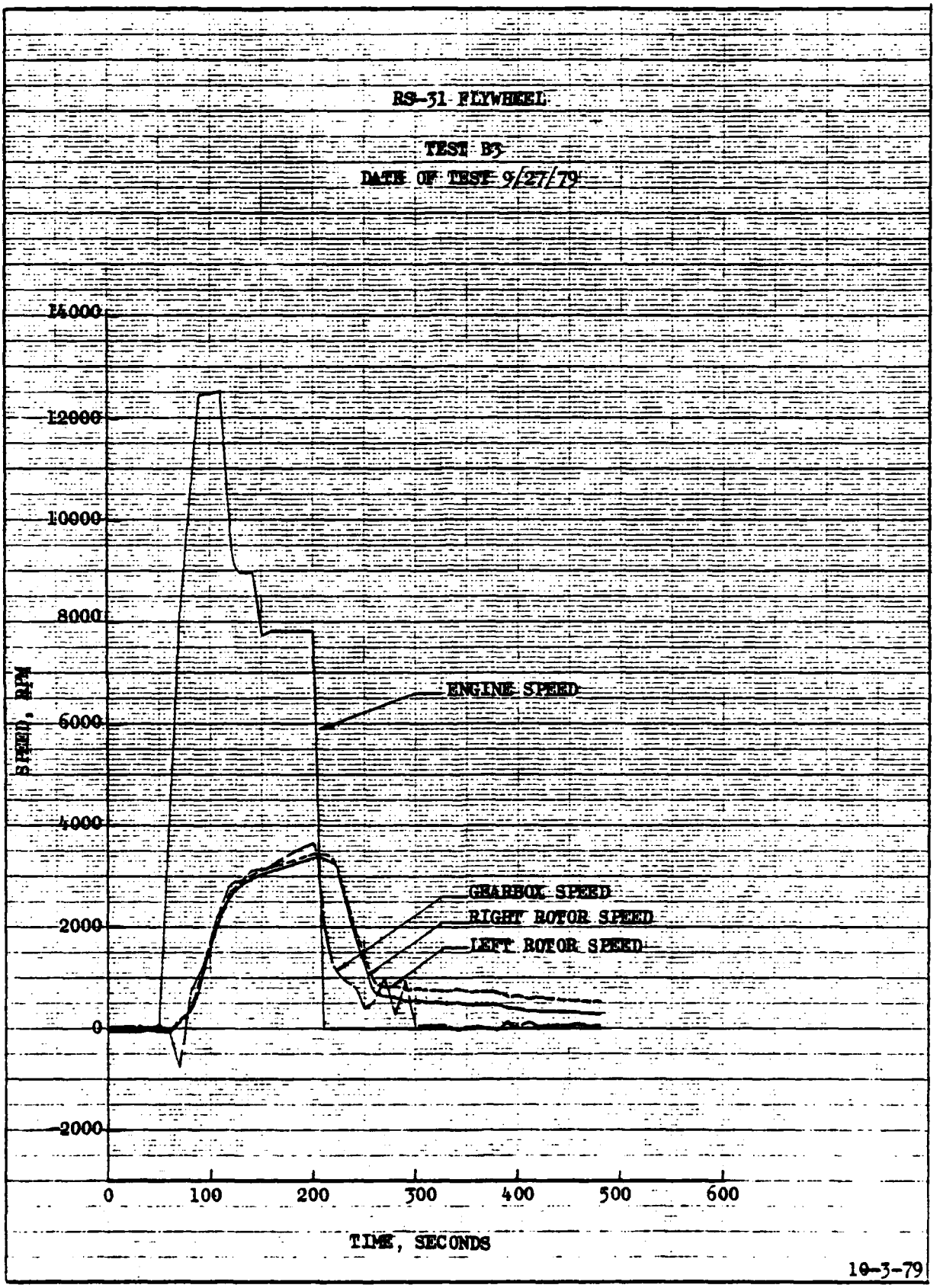
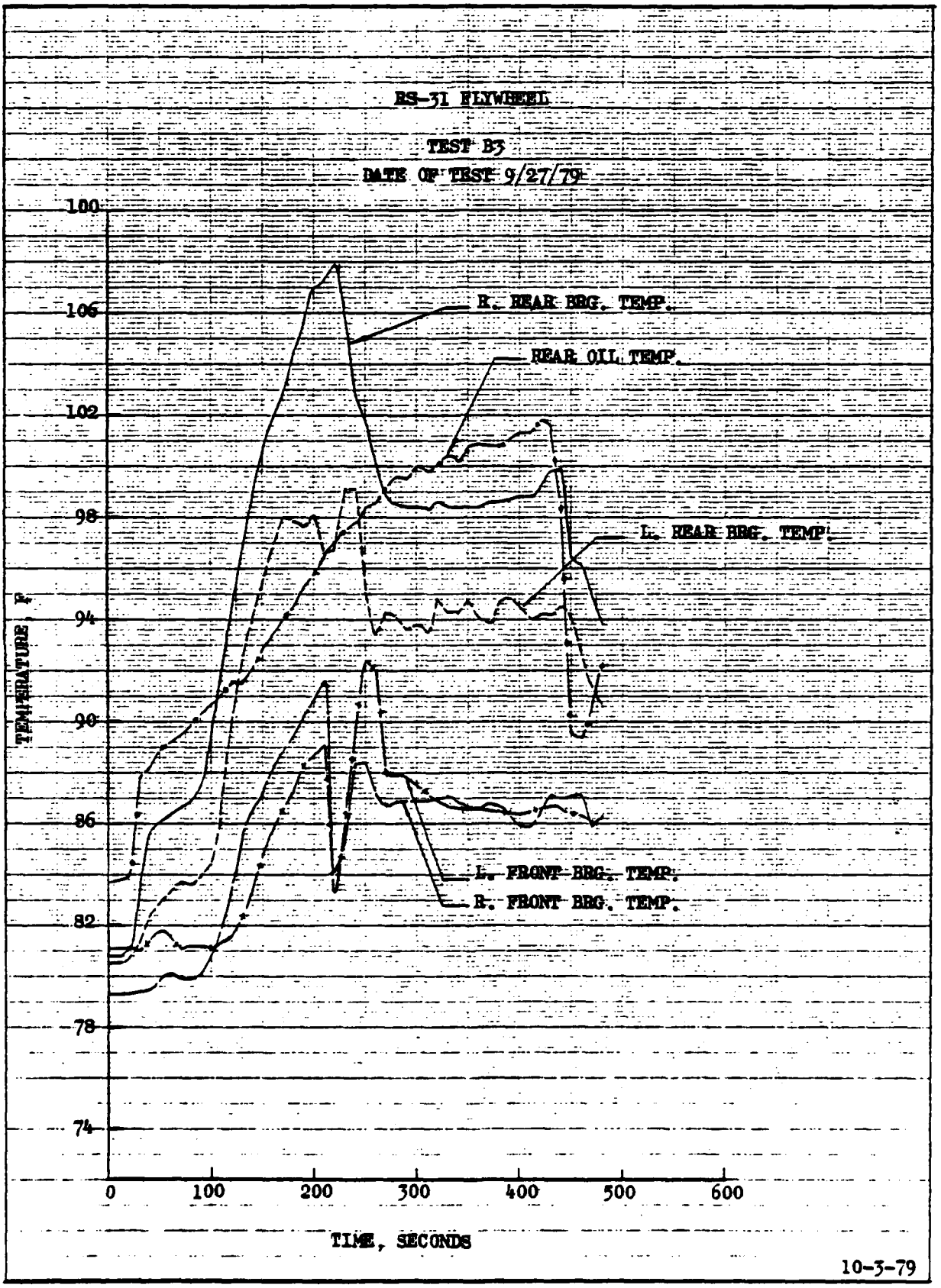
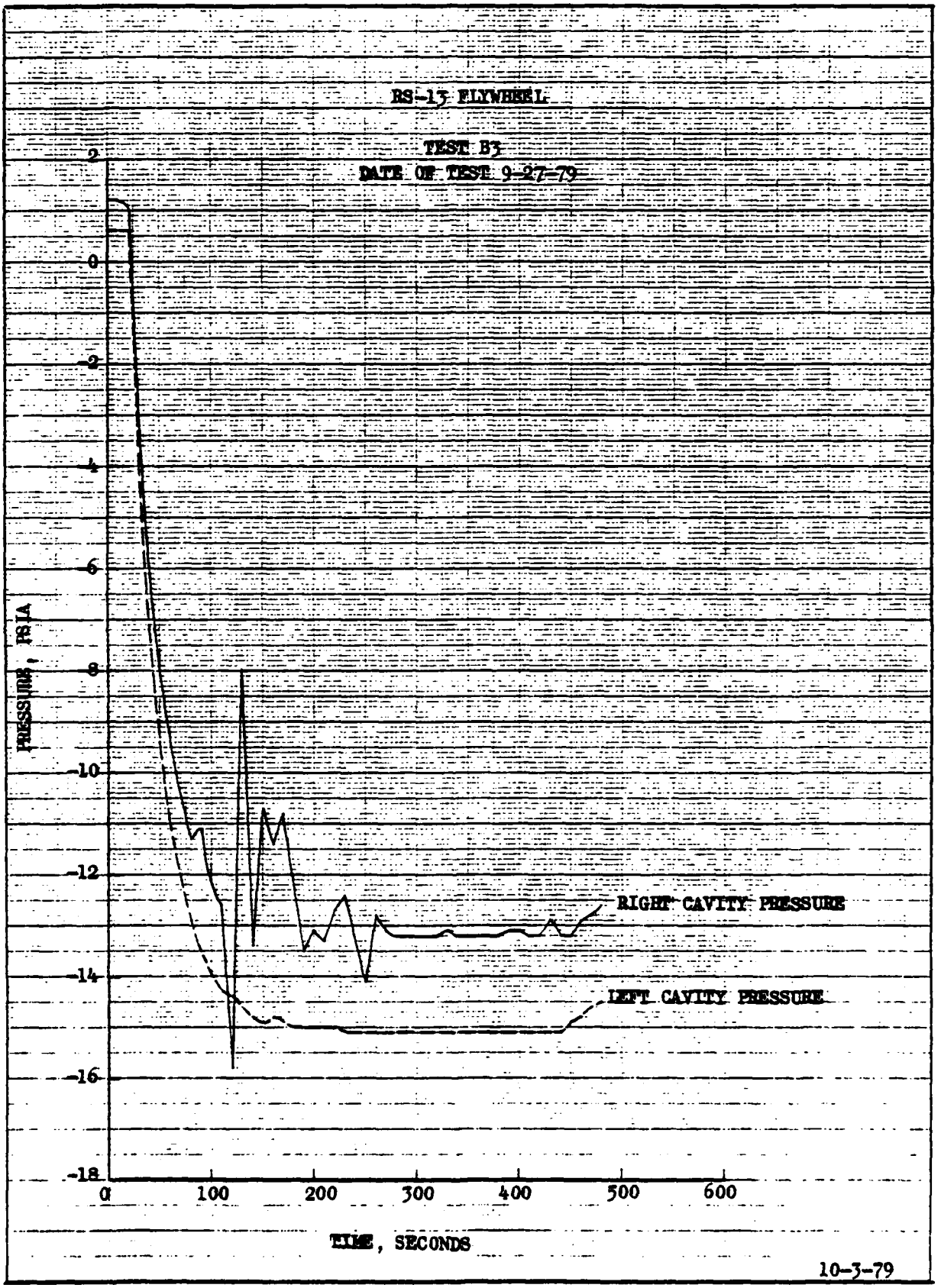
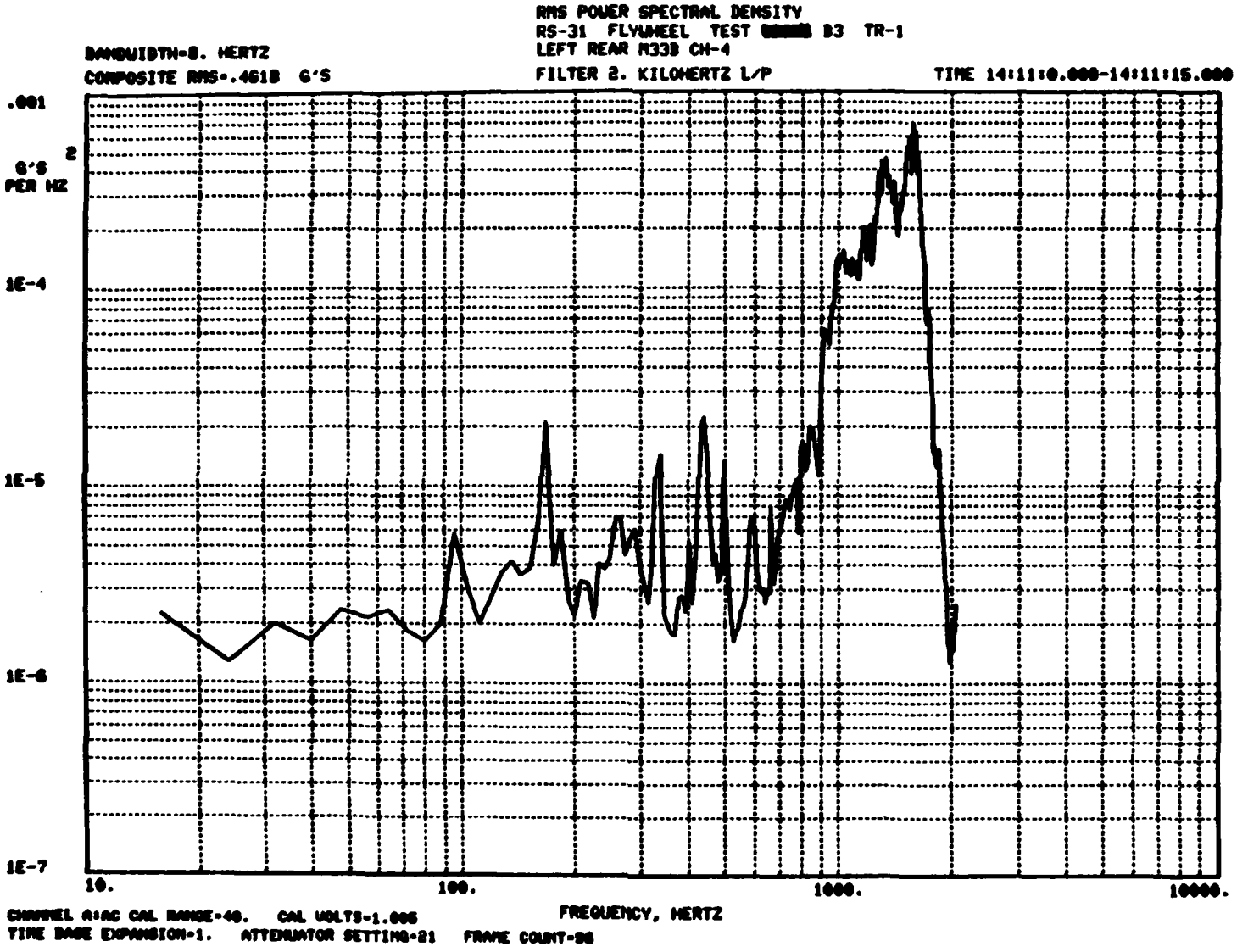
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

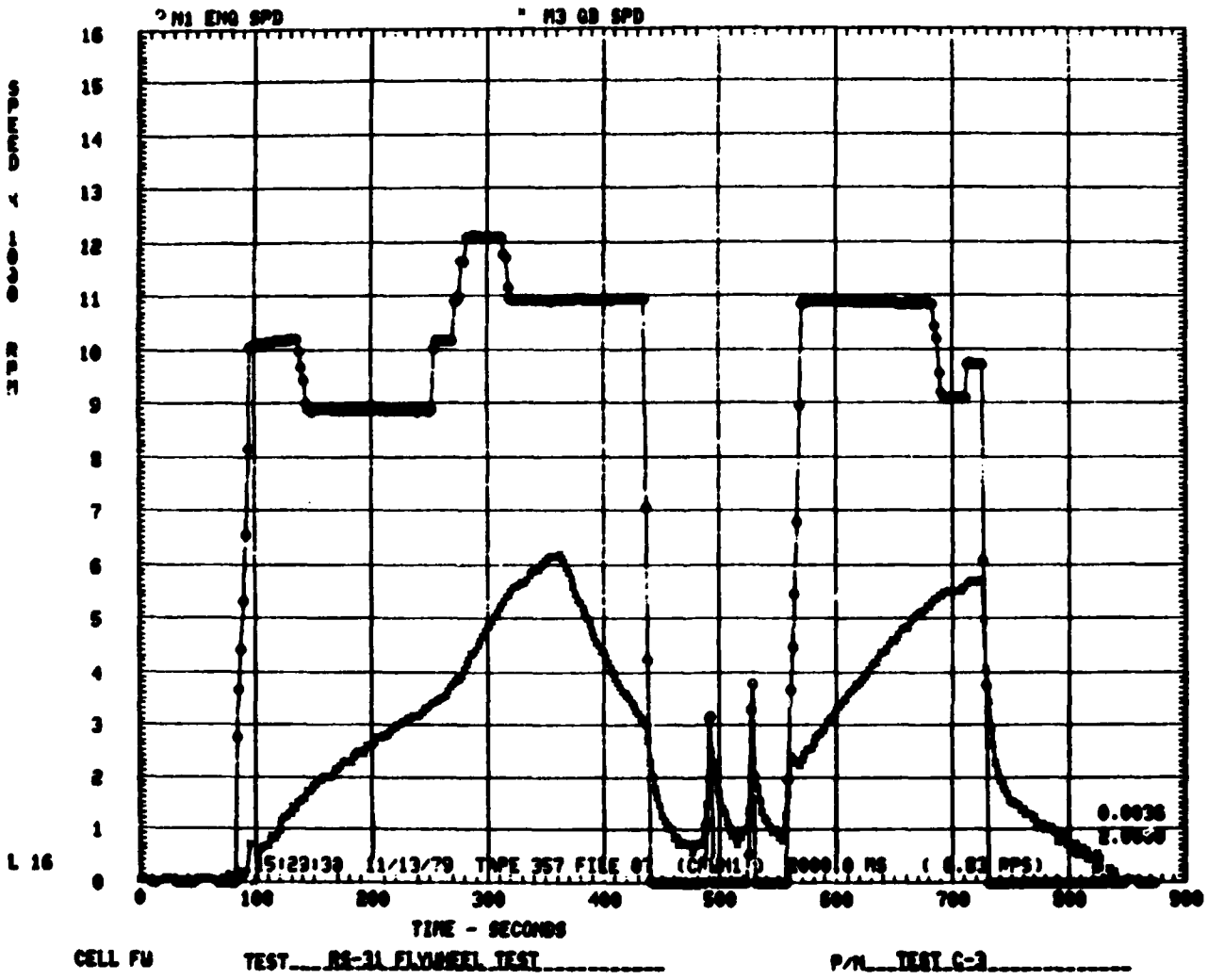

RMS POWER SPECTRAL DENSITY
RS-31 FLYWHEEL TEST 882 [redacted] TR-1
LEFT REAR R33B CH-4
BANDWIDTH-8. HERTZ
COMPOSITE RMS-.5986 G'S
FILTER 2. KILOHERTZ L/P
TIME 11:18:56.000-11:19:19.000
.01
G'S 2 PER HZ
.001
1E-4
1E-5
1E-6
10.
100.
1000.
10000.
FREQUENCY, HERTZ
CHANNEL A:AC CAL RANGE-40. CAL VOLTS-1.005
TIME BASE EXPANSION-1. ATTENUATOR SETTING-21 FRAME COUNT-147


RS-31 FLYWHEEL
TEST B3
DATE OF TEST 9/27/79
14000
12000
10000
8000
6000
4000
2000
0
-2000
SPEED, RPM
ENGINE SPEED
GEARBOX SPEED
RIGHT ROTOR SPEED
LEFT ROTOR SPEED
0
100
200
300
400
500
600
TIME, SECONDS
10-3-79

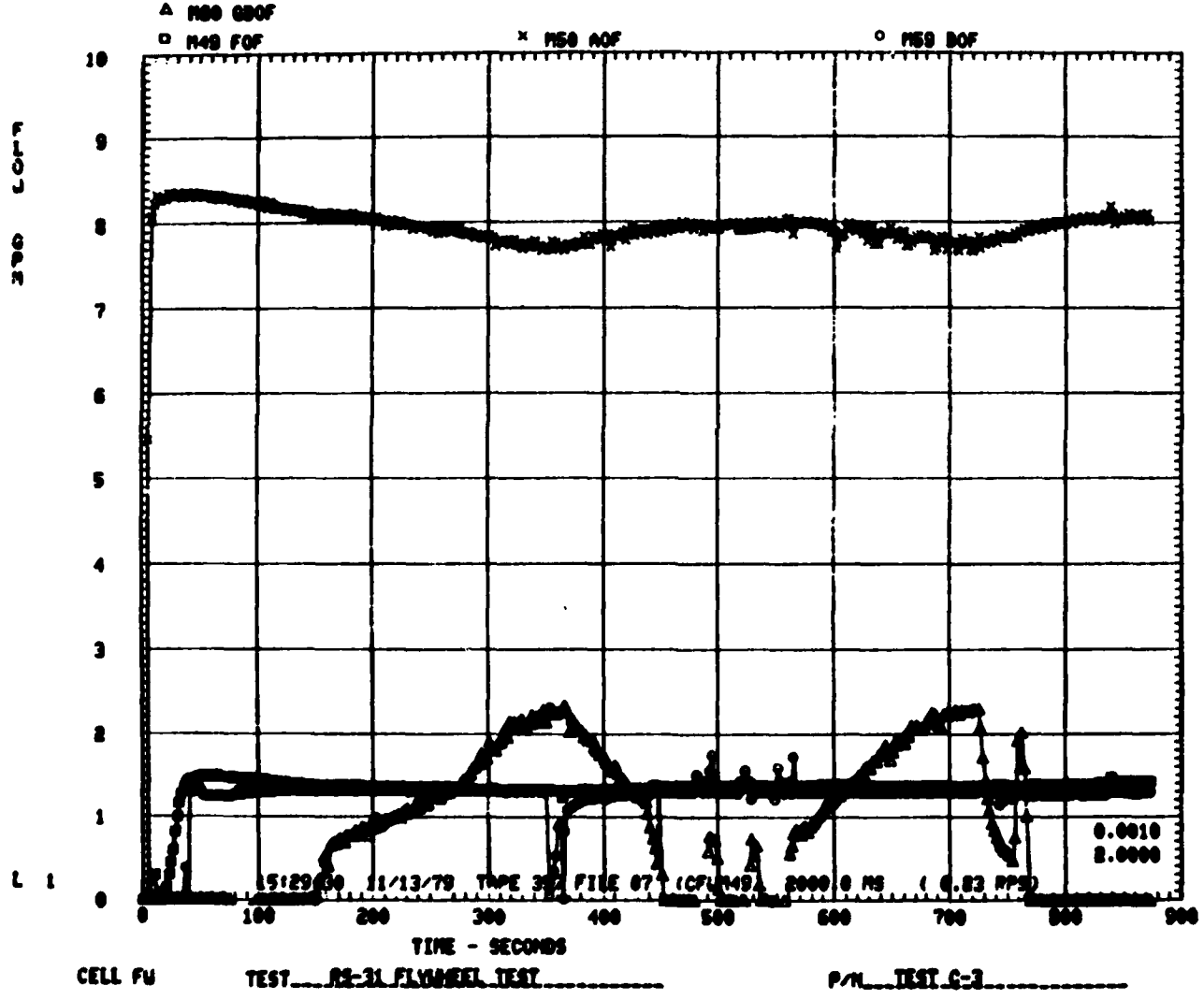

RS-31 FLYWHEEL
TEST B3
DATE OF TEST 9/27/79
100
106
102
98
94
90
86
82
78
74
TEMPERATURE F
R. REAR BRG. TEMP.
REAR OIL TEMP.
L. REAR BRG. TEMP.
L. FRONT BRG. TEMP.
R. FRONT BRG. TEMP.
0
100
200
300
400
500
600
TIME, SECONDS
10-3-79

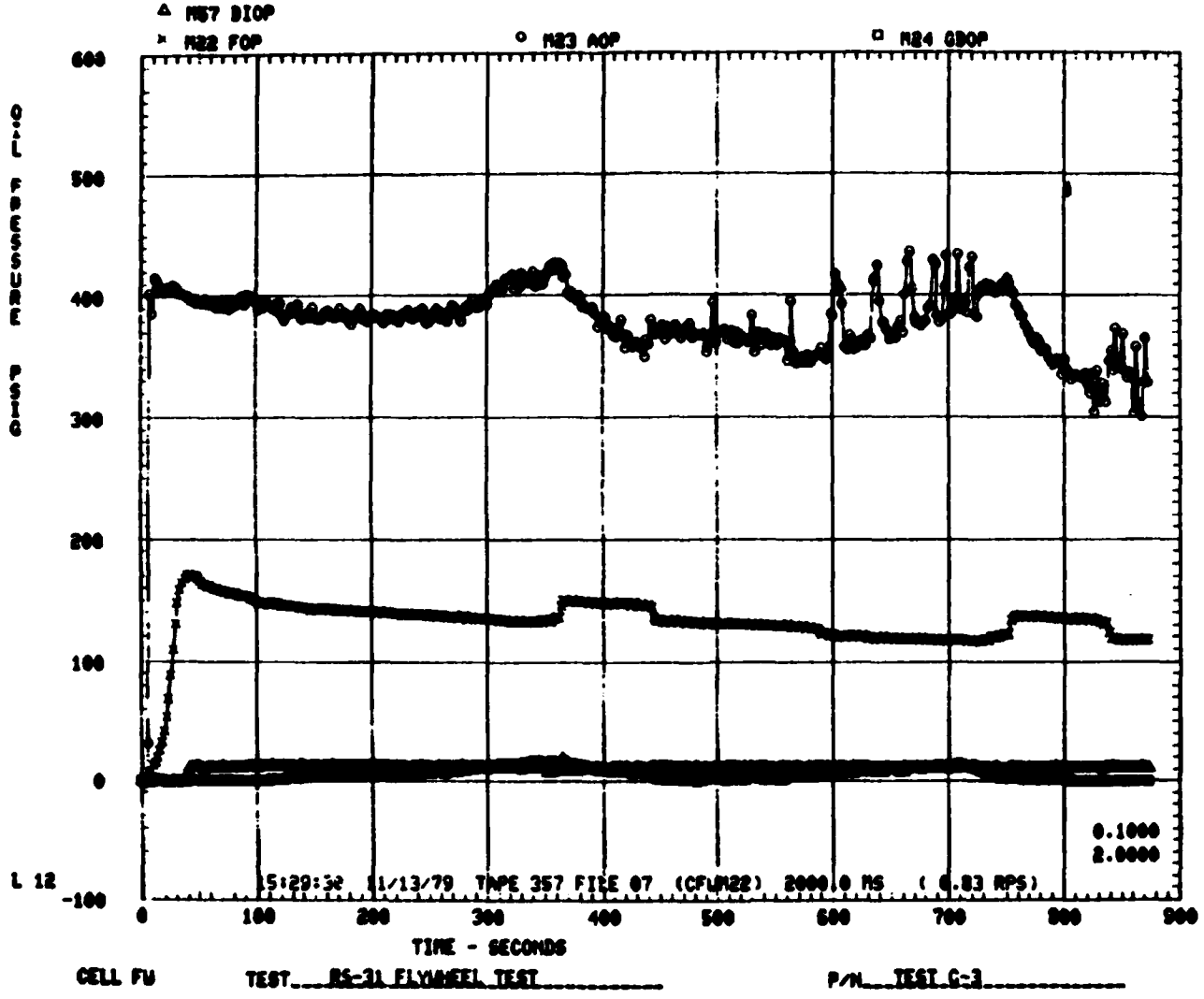

RS-13 FLYWHEEL
TEST B3
DATE OF TEST 9-27-79
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
PRESSURE, PSIA
0
100
200
300
400
500
600
TIME, SECONDS
RIGHT CAVITY PRESSURE
LEFT CAVITY PRESSURE
10-3-79

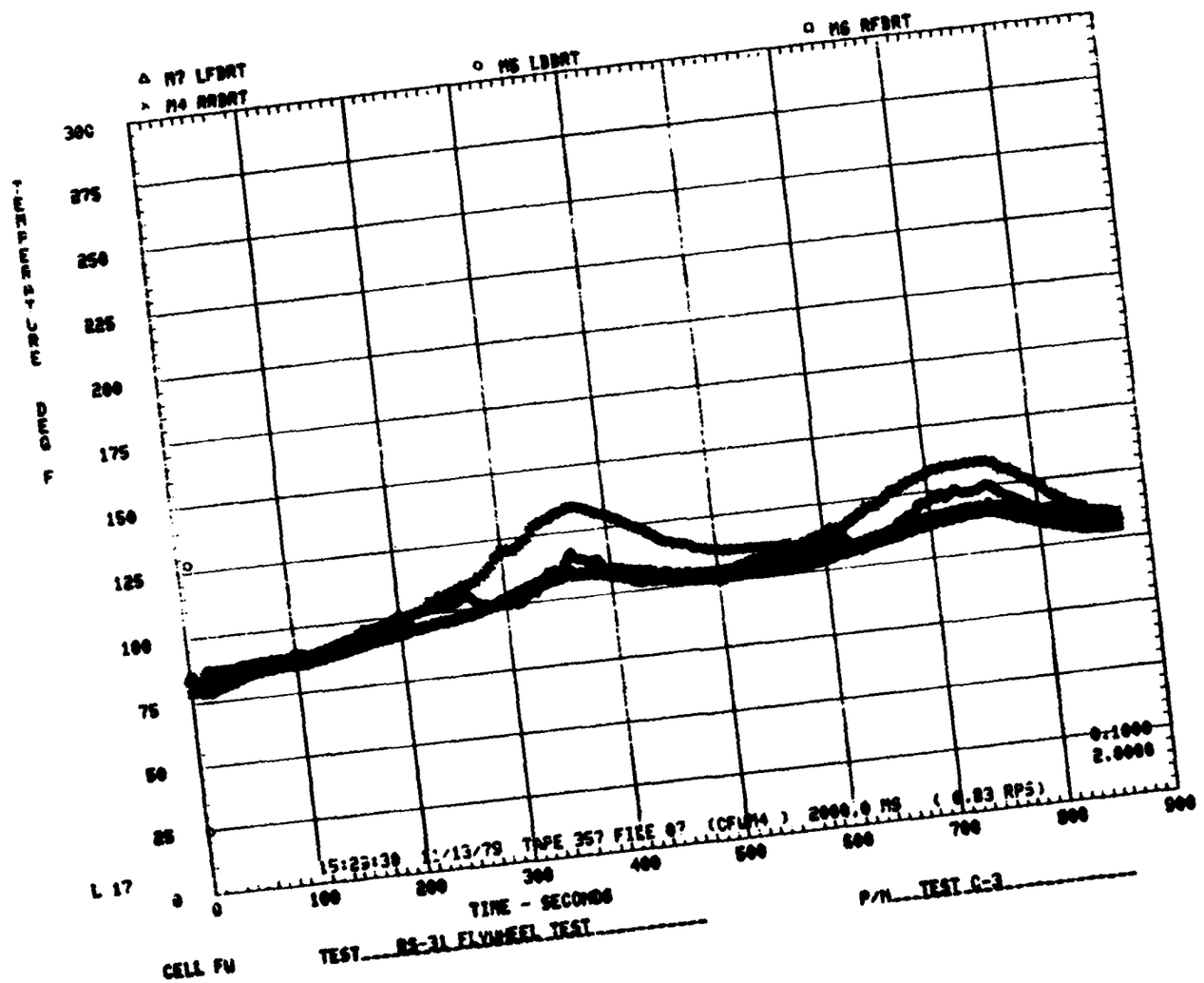

RMS POWER SPECTRAL DENSITY
RS-31 FLYWHEEL TEST [redacted] B3 TR-1
LEFT REAR R33B CH-4
BANDWIDTH-8. HERTZ
COMPOSITE RMS-.4618 G'S
FILTER 2. KILOHERTZ L/P
TIME 14:11:0.000-14:11:15.000
.001
G'S 2 PER HZ
1E-4
1E-5
1E-6
1E-7
10.
100.
1000.
10000.
FREQUENCY, HERTZ
CHANNEL A:AC CAL RANGE-40. CAL VOLTS-1.006
TIME BASE EXPANSION-1. ATTENUATOR SETTING-21 FRAME COUNT-96

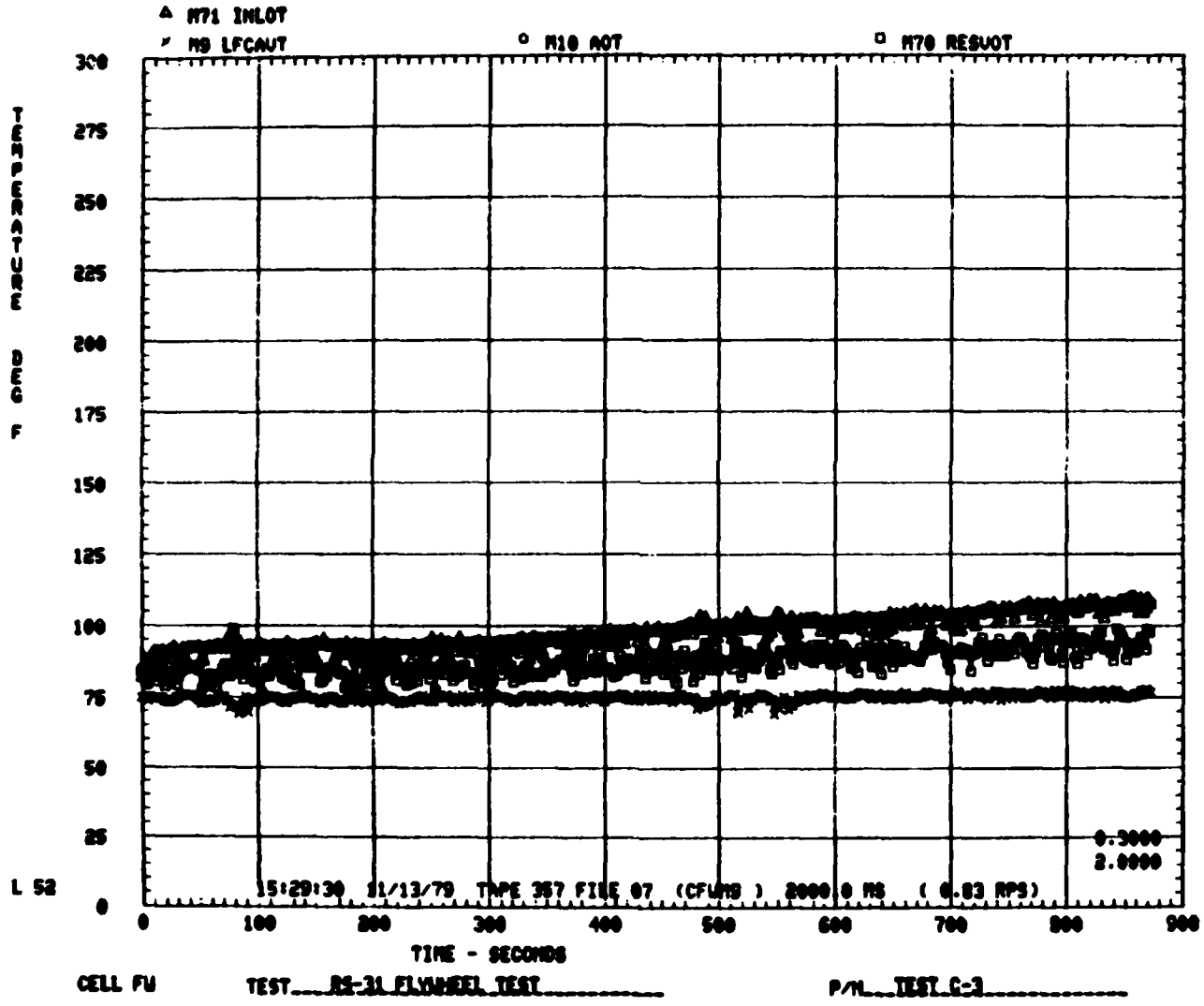


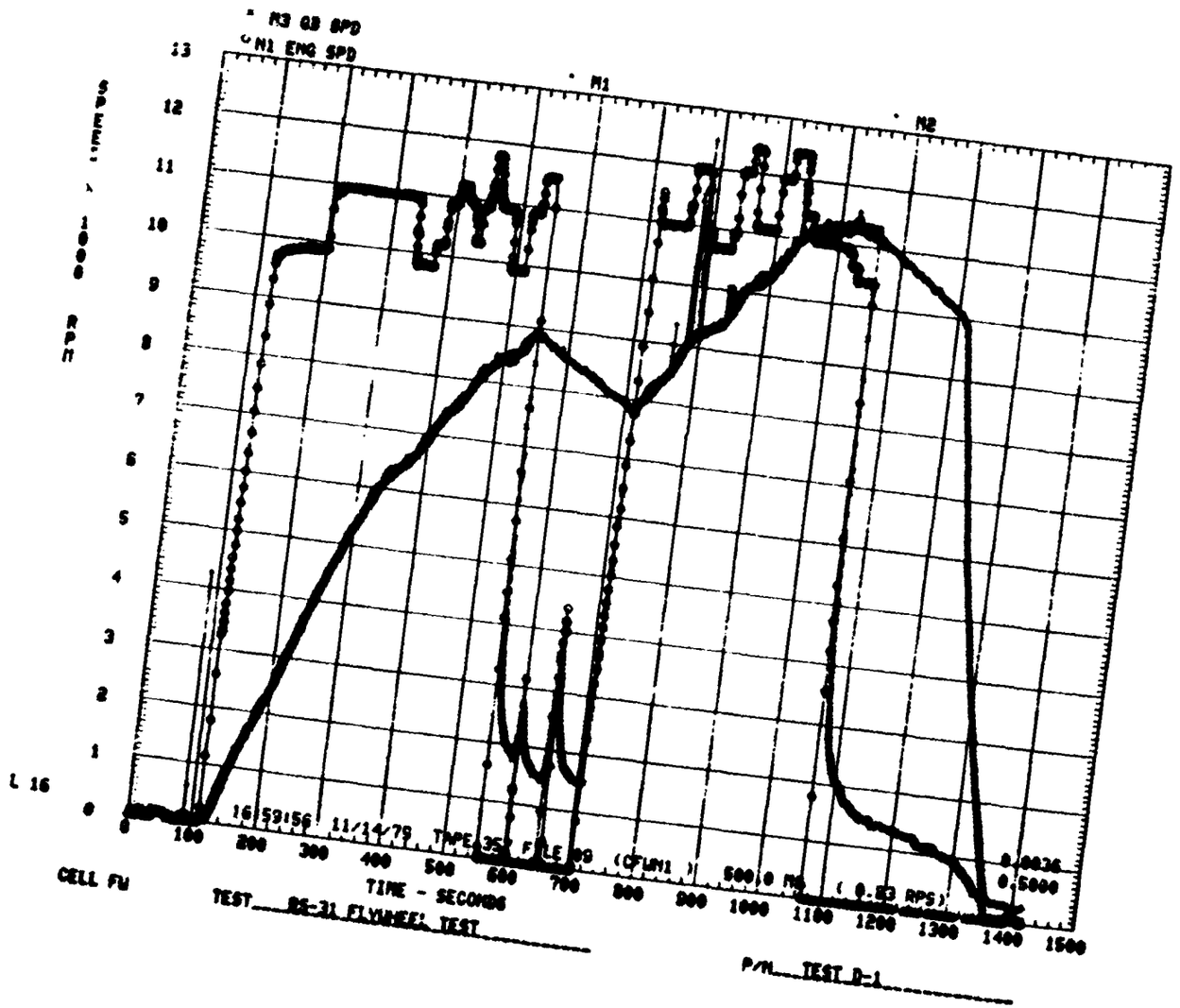
CELL FU TEST RS-31 FLYWHEEL TEST P/N TEST C-3

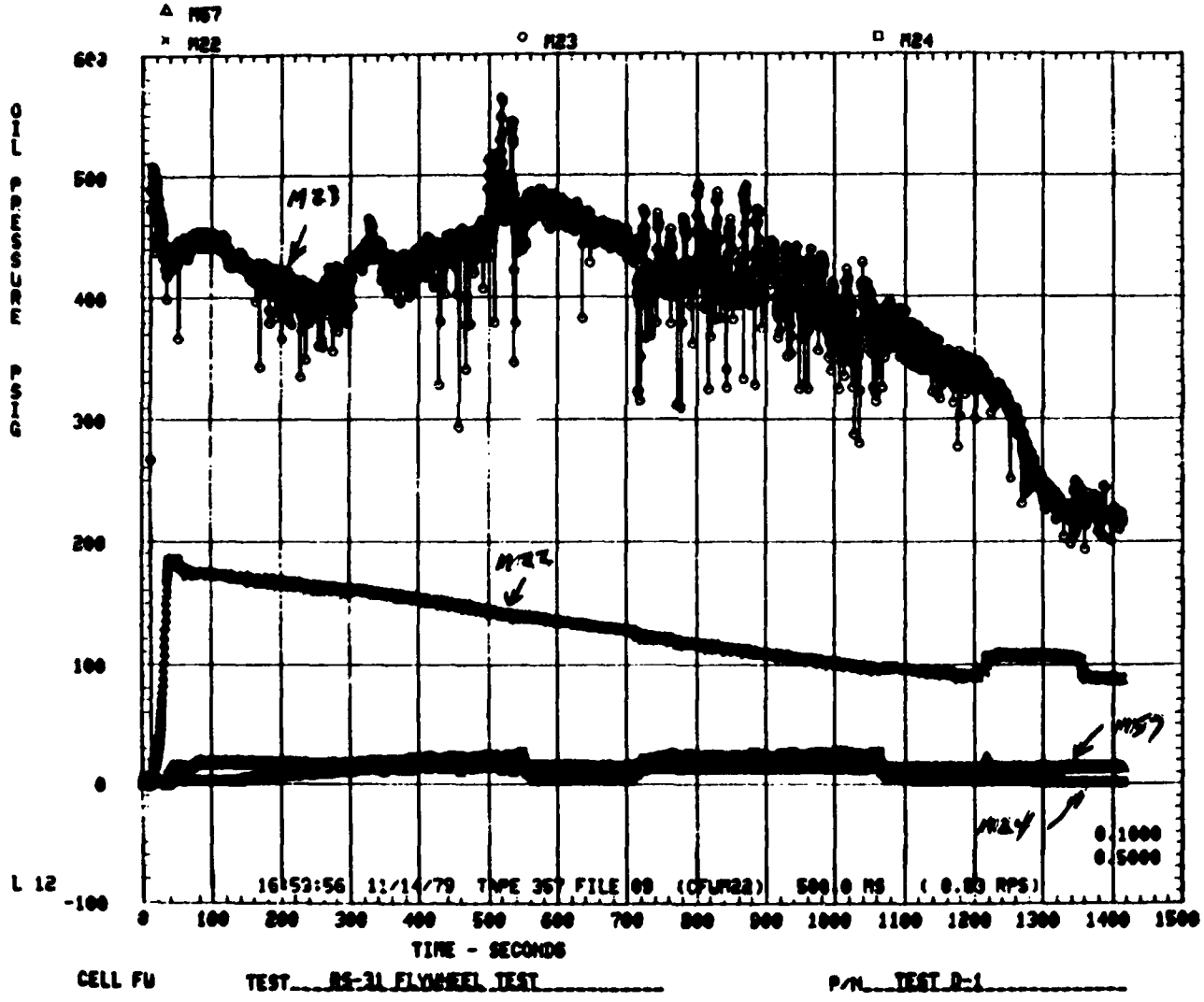

M80 GBOF
M49 FOF
M59 AOF
M59 BOF
M80 LOFR
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
600
700
800
900
TIME - SECONDS
0.0010
8.0000
L 1
15:29:00 11/13/79 TAPE 3?? FILE 07? (CFU49) 2000.0 MS (0.83 PPS)
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST C-3

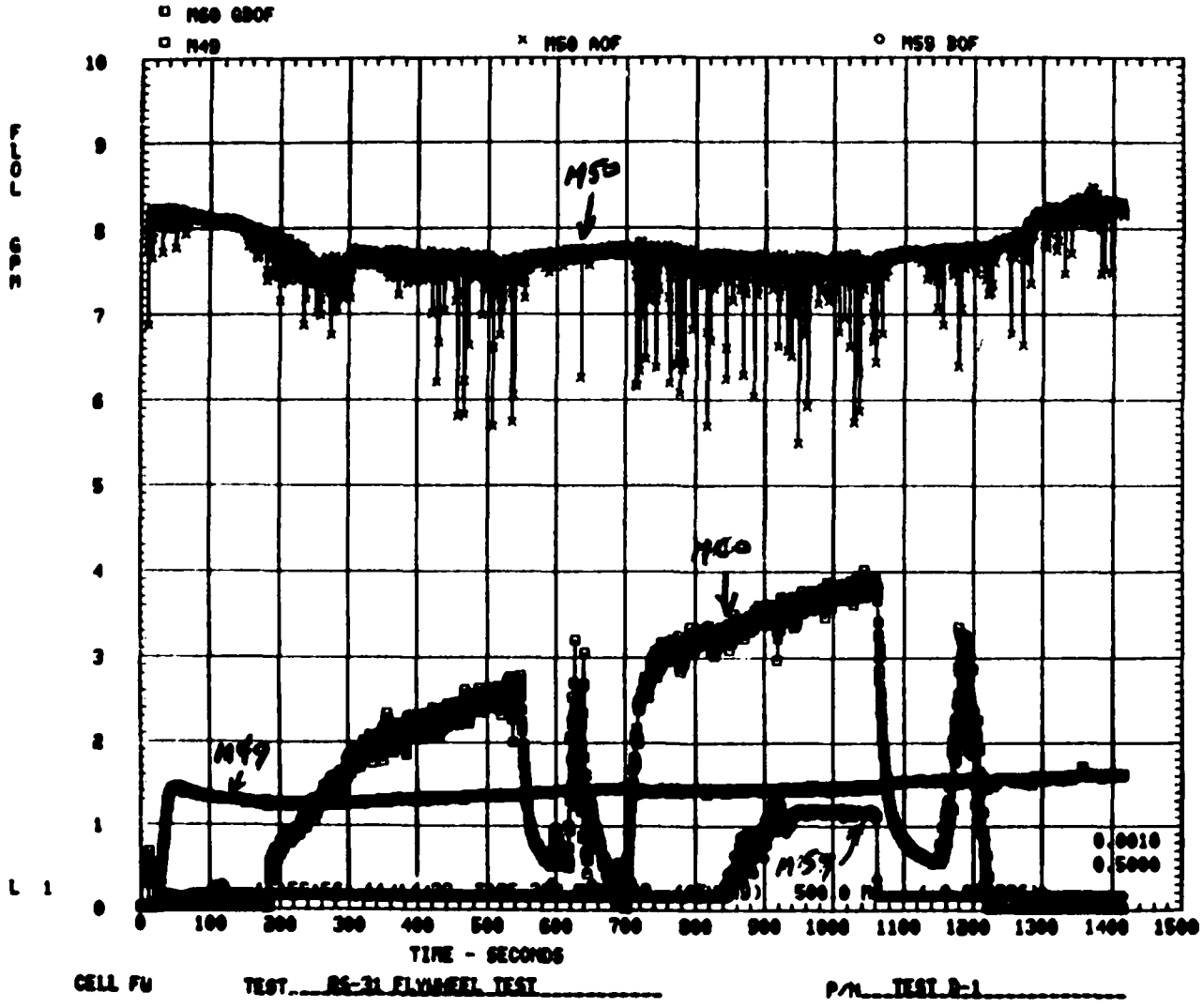

M57 DIOP
M22 FOP
M23 AOP
M24 GBOP
600
500
400
300
200
100
0
-100
0.1000
2.0000
15:29:32 11/13/79 TAPE 357 FILE 07 (CFUM22) 2000.0 MS (6.83 RPS)
0
100
200
300
400
500
600
700
800
900
TIME - SECONDS
L 12
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST C-3

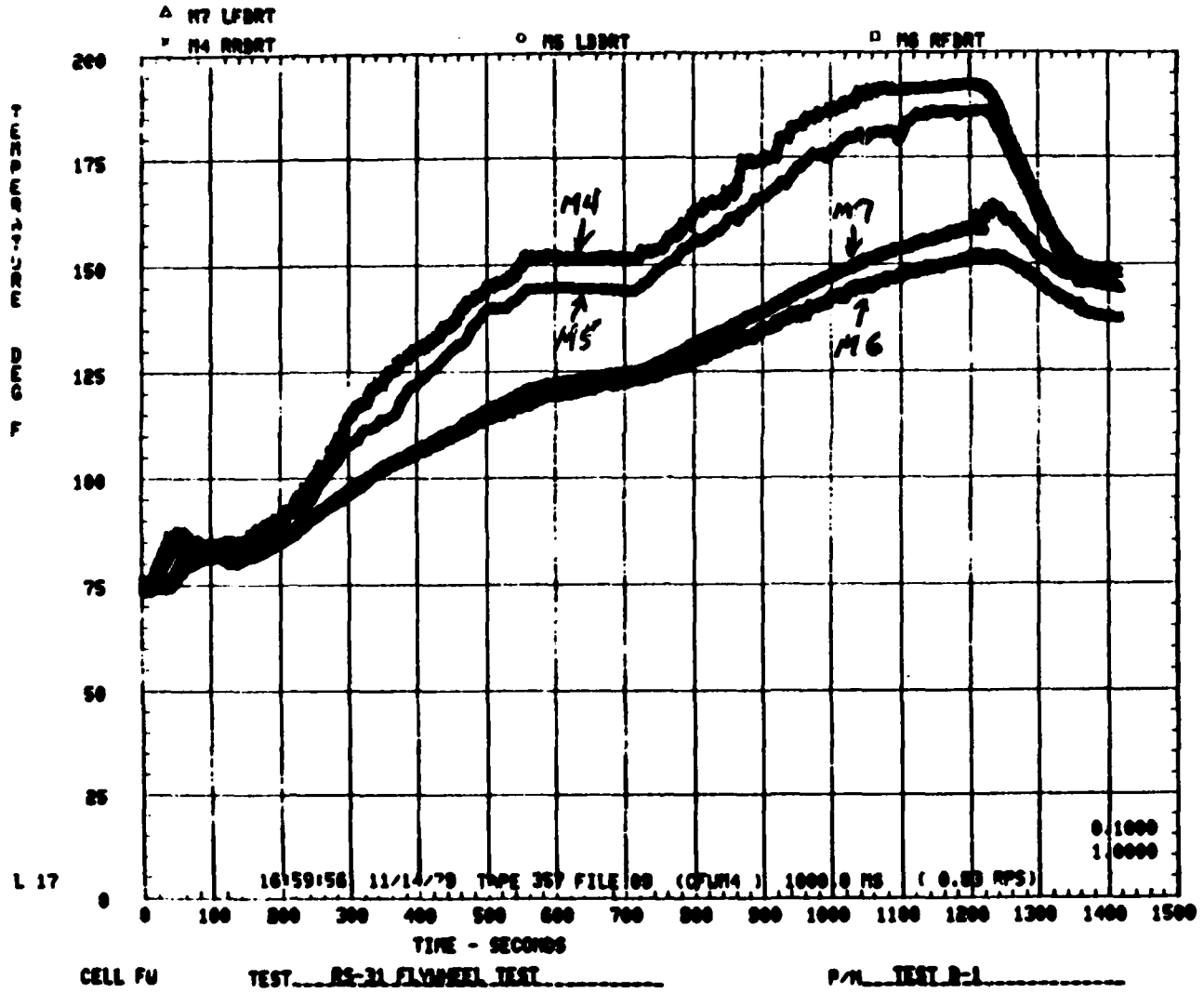

M7 LFBRT
M4 RRBRT
M5 LBBRT
M6 RFBRT
300
275
250
225
200
175
150
125
100
75
50
25
0
0
100
200
300
400
500
600
700
800
900
TIME - SECONDS
0:1000
2.0000
15:23:38 1/13/79 TAPE 357 FILE 07 (CFLM4) 2000.0 MS (0.83 RPS)
L 17
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST C-3

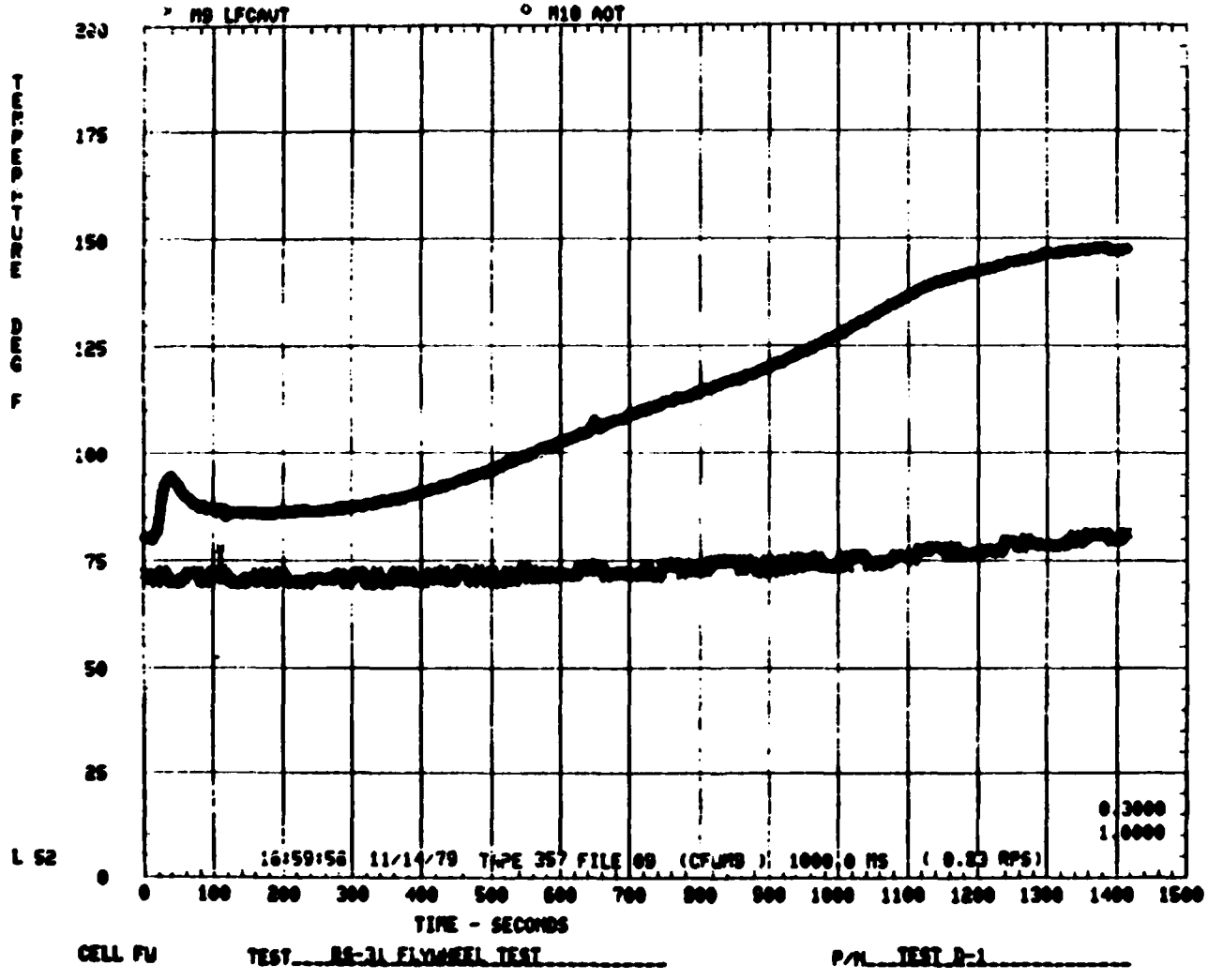

△ M71 INLOT
▾ M9 LFCAUT
○ M10 AOT
□ M70 RESUOT
TEMPERATURE DEG F
300
275
250
225
200
175
150
125
100
75
50
25
0
0
100
200
300
400
500
600
700
800
900
TIME - SECONDS
0.3000
2.0000
15:29:30 01/13/79 TAPE 367 FILE 07 (CFUM9) 2000.0 MS (0.83 RPS)
L 52
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST C-3

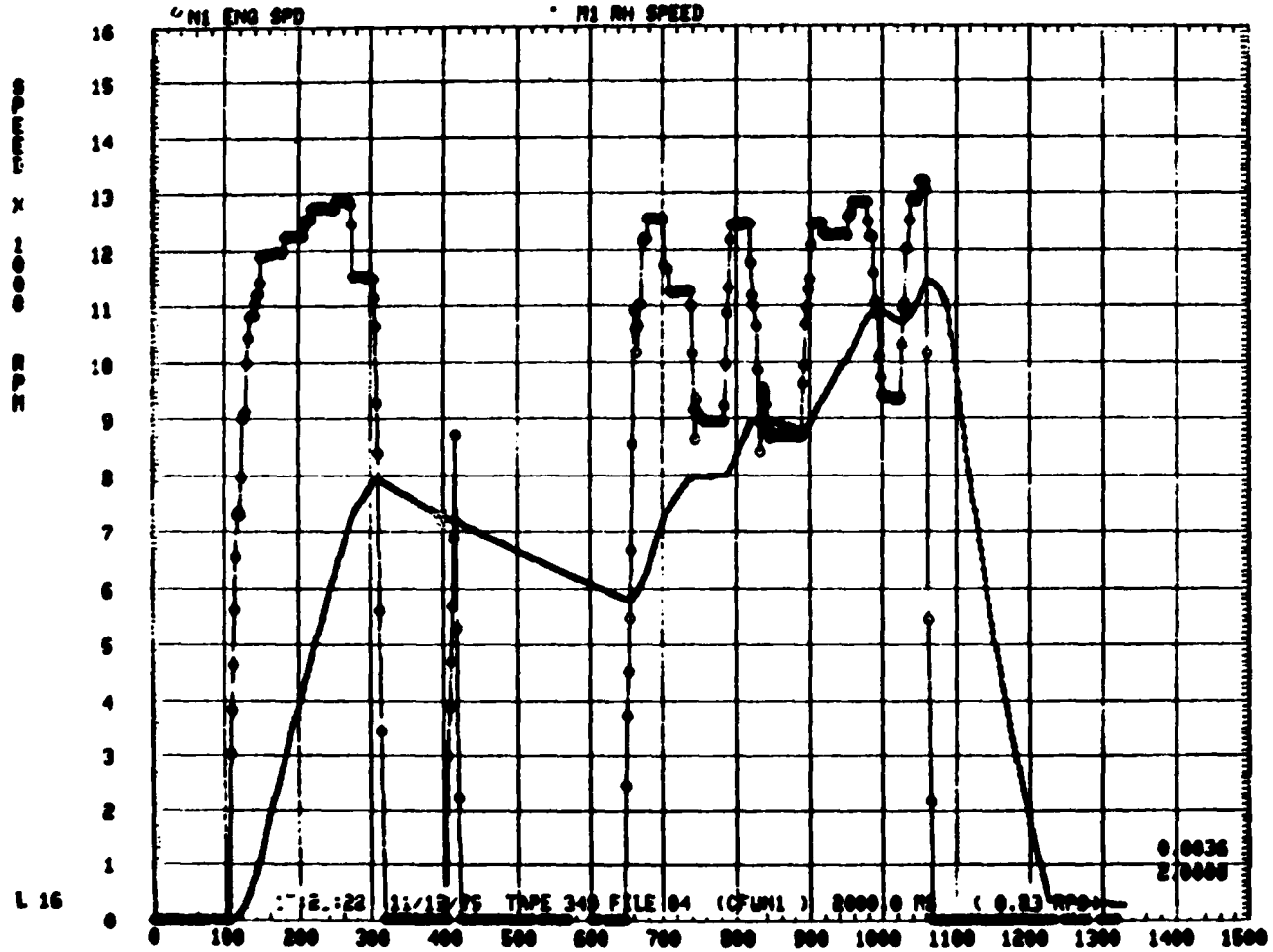

R3 GB SPD
N1 ENG SPD
N1
N2
SPEED - RPM
13
12
11
10
9
8
7
6
5
4
3
2
1
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TIME - SECONDS
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST D-1


△ M27
× M22
○ M23
□ M24
600
500
400
300
200
100
0
-100
GH2 PRESSURE PSIG
M23
M22
M27
M24
0.1000
0.5000
L 12
16:52:56 11/14/79 TAPE 357 FILE 09 (CFUM22) 500.0 MS (0.83 RPS)
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
TIME - SECONDS
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST D-1


M50 GBOF
M49
M50 AOF
M50 BOF
FLOW GPM
10
9
8
7
6
5
4
3
2
1
0
M50
M49
M60
M57
0.0010
0.5000
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TIME - SECONDS
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST B-1

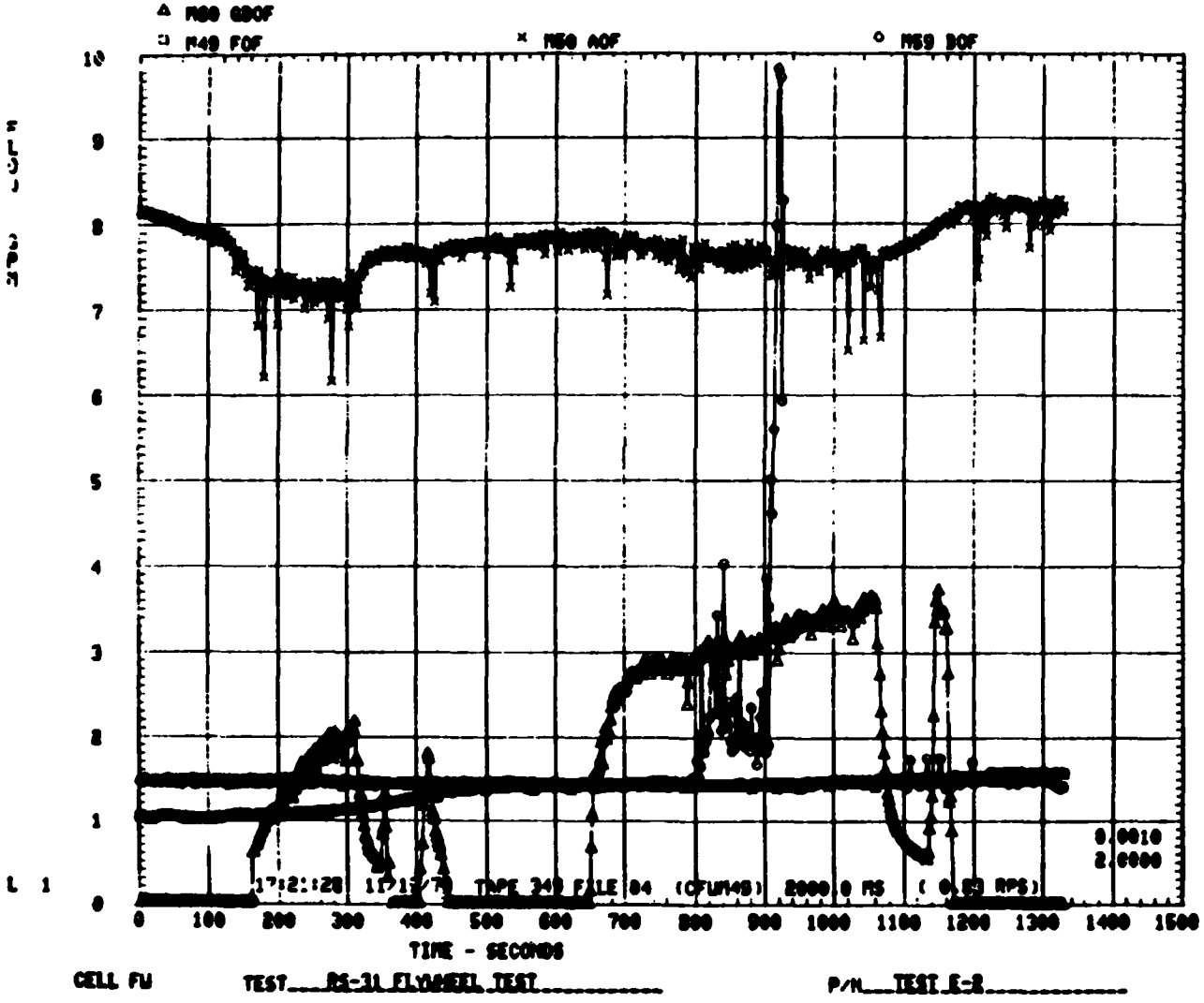

Δ M7 LFBRT
▽ M4 RRBRT
○ M5 LBBRT
□ M6 RFBRT
TEMPERATURE DEG F
200
175
150
125
100
75
50
25
0
M4
M5
M7
M6
0 1000
1 0000
L 17
16:59:58 11/14/79 TAPE 357 FILE 00 (CFLM14) 1000.0 MS (0.00 RPS)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TIME - SECONDS
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST B-1


* R9 LFCAUT
° R10 AOT
TEMPERATURE DEG F
225
175
150
125
100
75
50
25
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
TIME - SECONDS
0.3000
1.0000
16:59:56 11/14/79 TAPE 357 FILE 09 (CFLWB) 1000.0 MS (0.83 RPS)
L 52
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST D-1

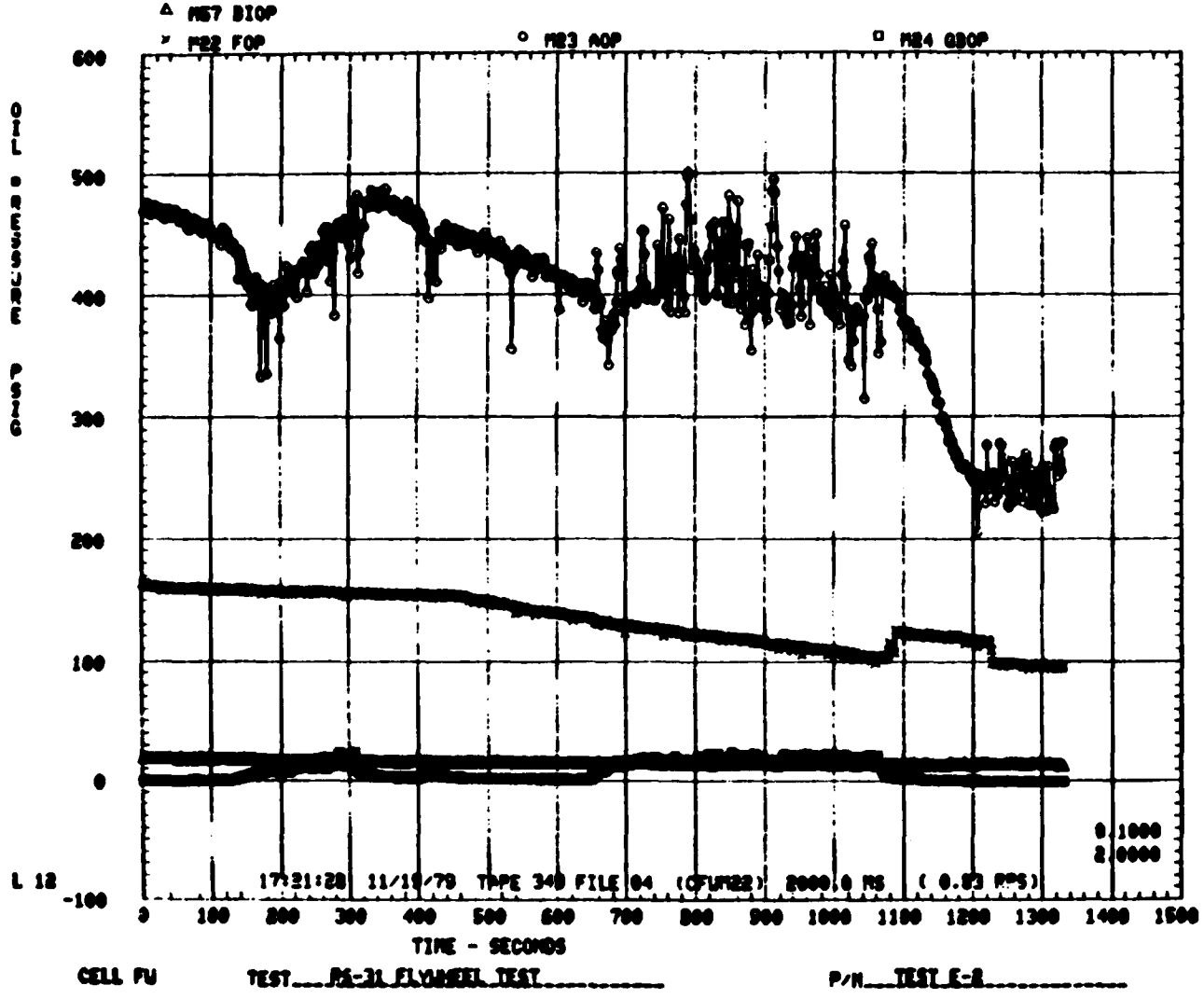


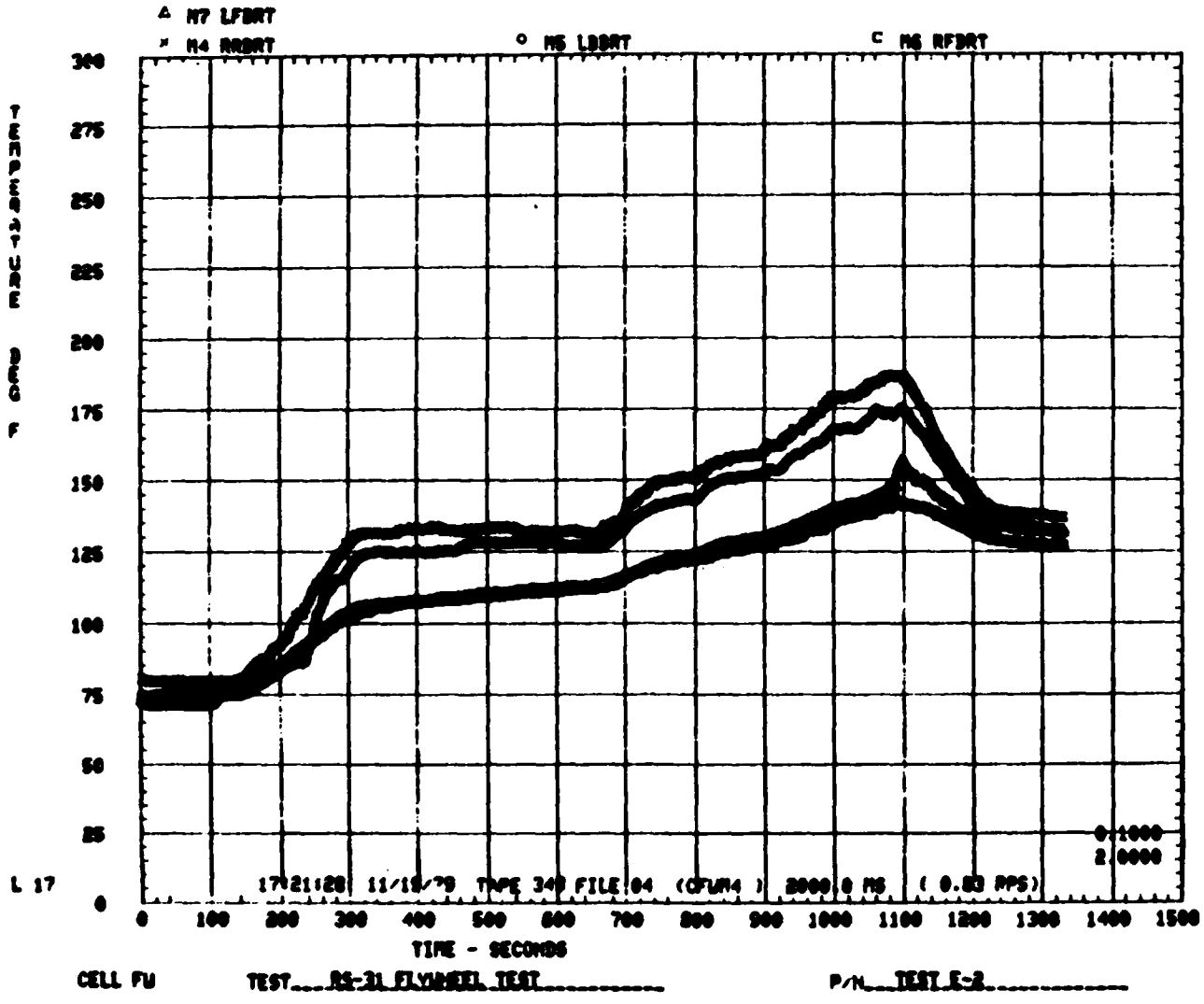
L 16

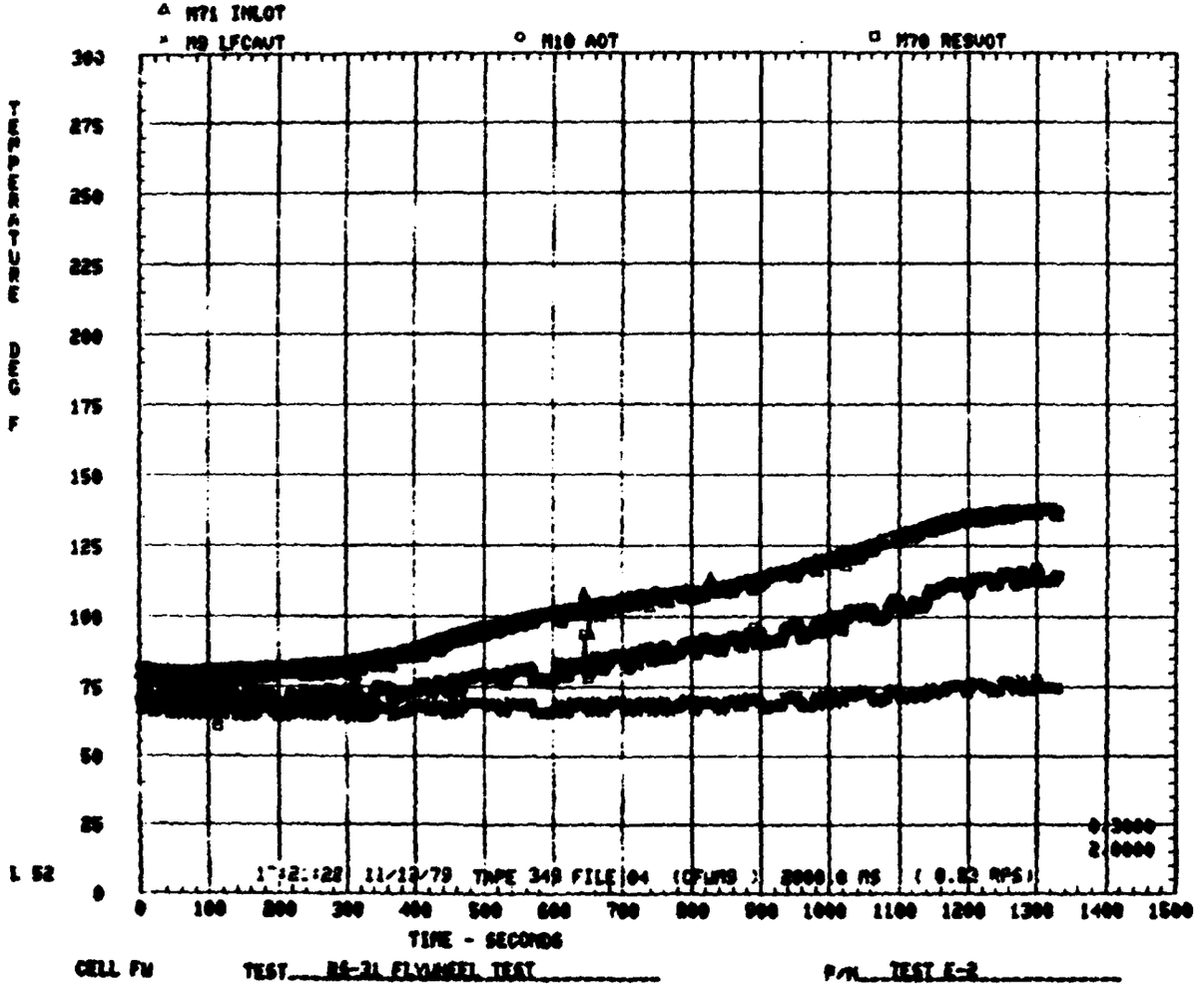
CELL FU TEST RS-31 FLIGHTEL TEST P/N TEST E-2

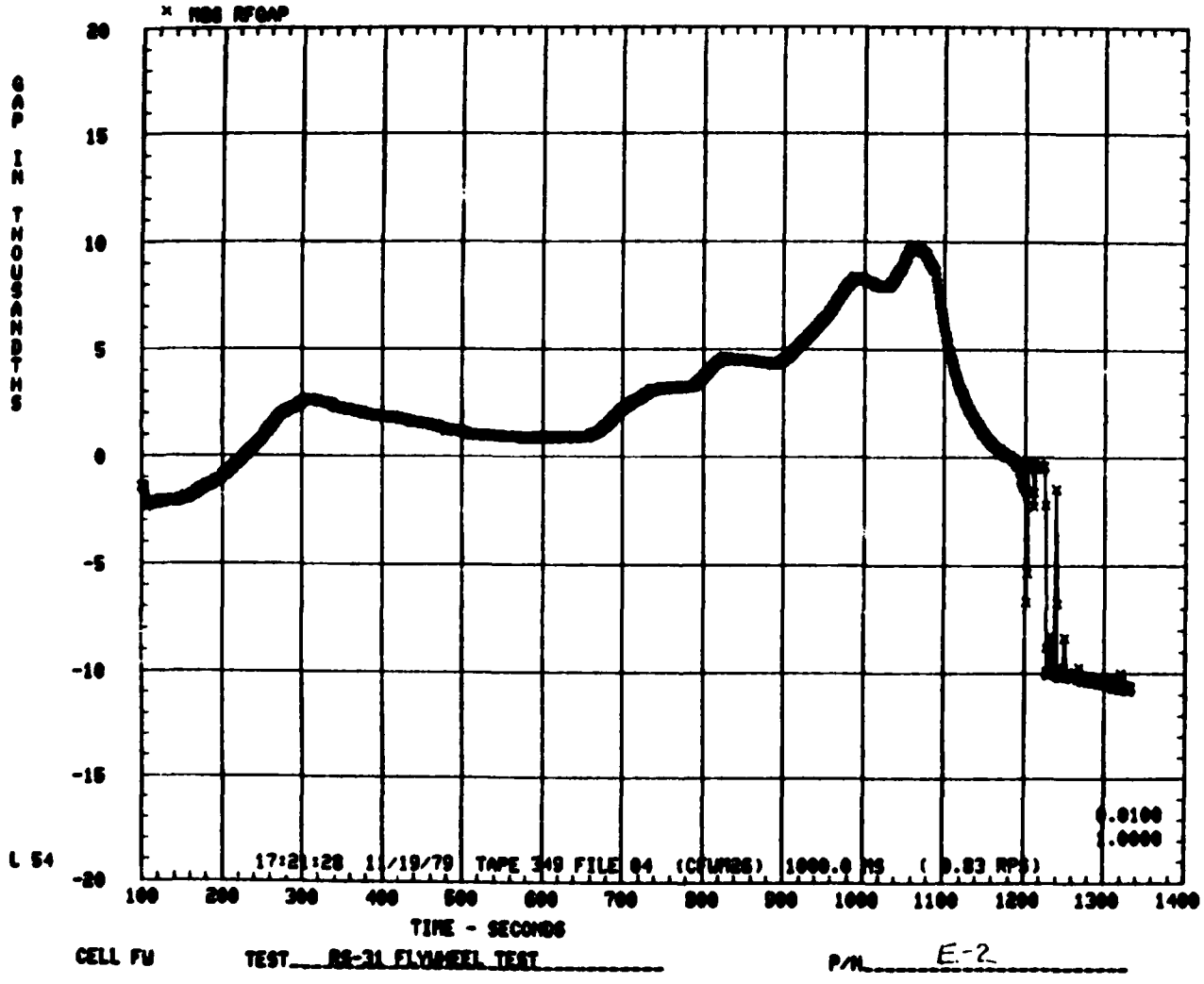


CELL FU TEST RS-31 FLYWHEEL TEST P/N TEST E-8

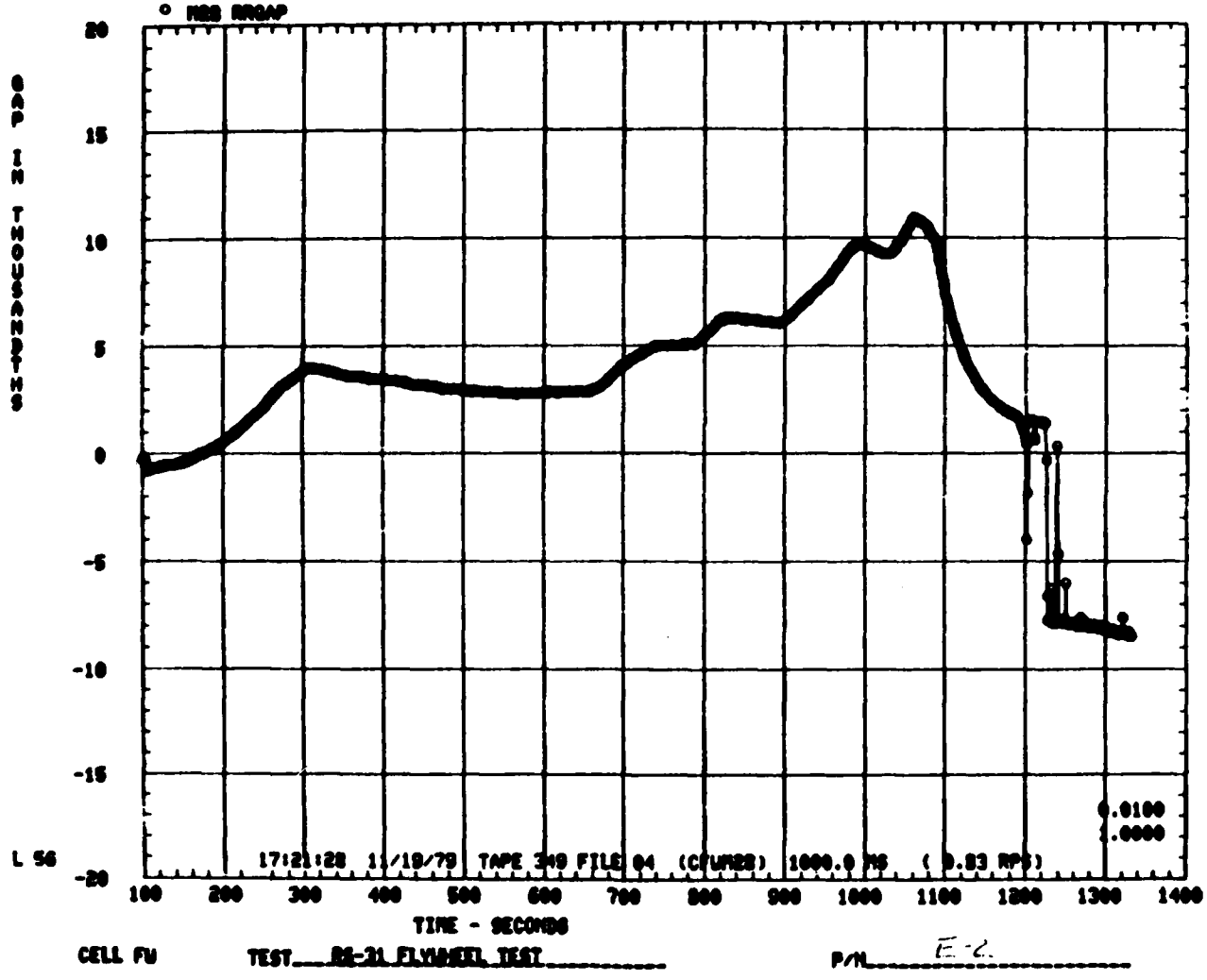

MS7 BIOP
MS2 FOP
MS3 AOP
MS4 GBOP
OIL PRESSURE PSIG
600
500
400
300
200
100
0
-100
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TIME - SECONDS
0.1000
2.0000
L 12
17:21:28 11/19/79 TAPE 340 FILE 04 (CFUN22) 2000.0 MS (0.83 PPS)
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST E-8


Δ M7 LFBRT
x M4 RRBRT
o M5 LBBRT
c M6 RFBRT
TEMPERATURE DEG F
300
275
250
225
200
175
150
125
100
75
50
25
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
TIME - SECONDS
0.1000
2.0000
L 17
17:21:28 11/15/79 TAPE 349 FILE 04 (CFUN4) 2000.0 MS (0.83 RPS)
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST E-2

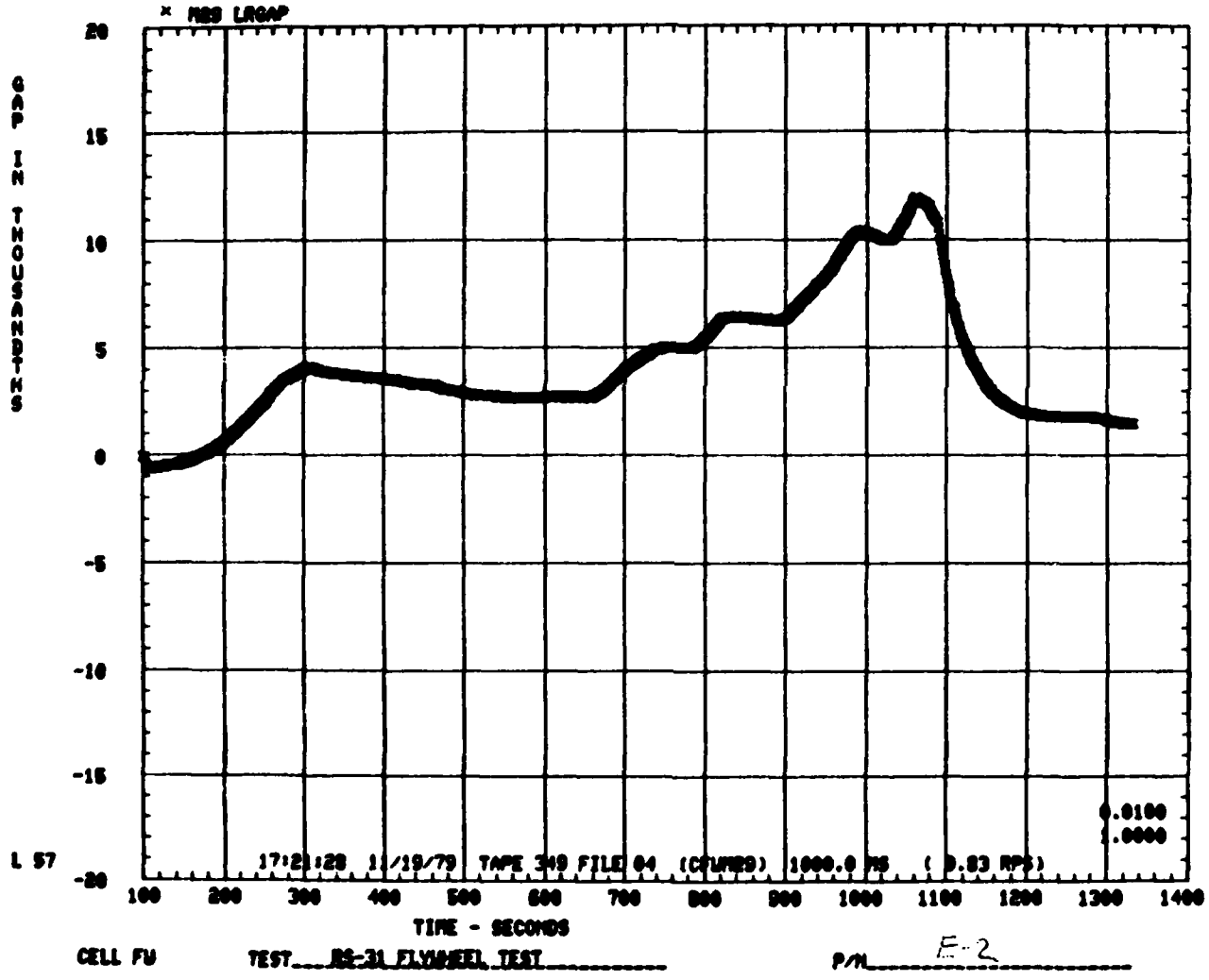

△ M71 INLOT
+ M9 LFCAUT
○ M10 AOT
□ M70 RESUOT
TEMPERATURE DEG F
300
275
250
225
200
175
150
125
100
75
50
25
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
TIME - SECONDS
0.3000
2.0000
L 52
CELL FW
TEST RS-31 FLYWHEEL TEST
P/N TEST E-2

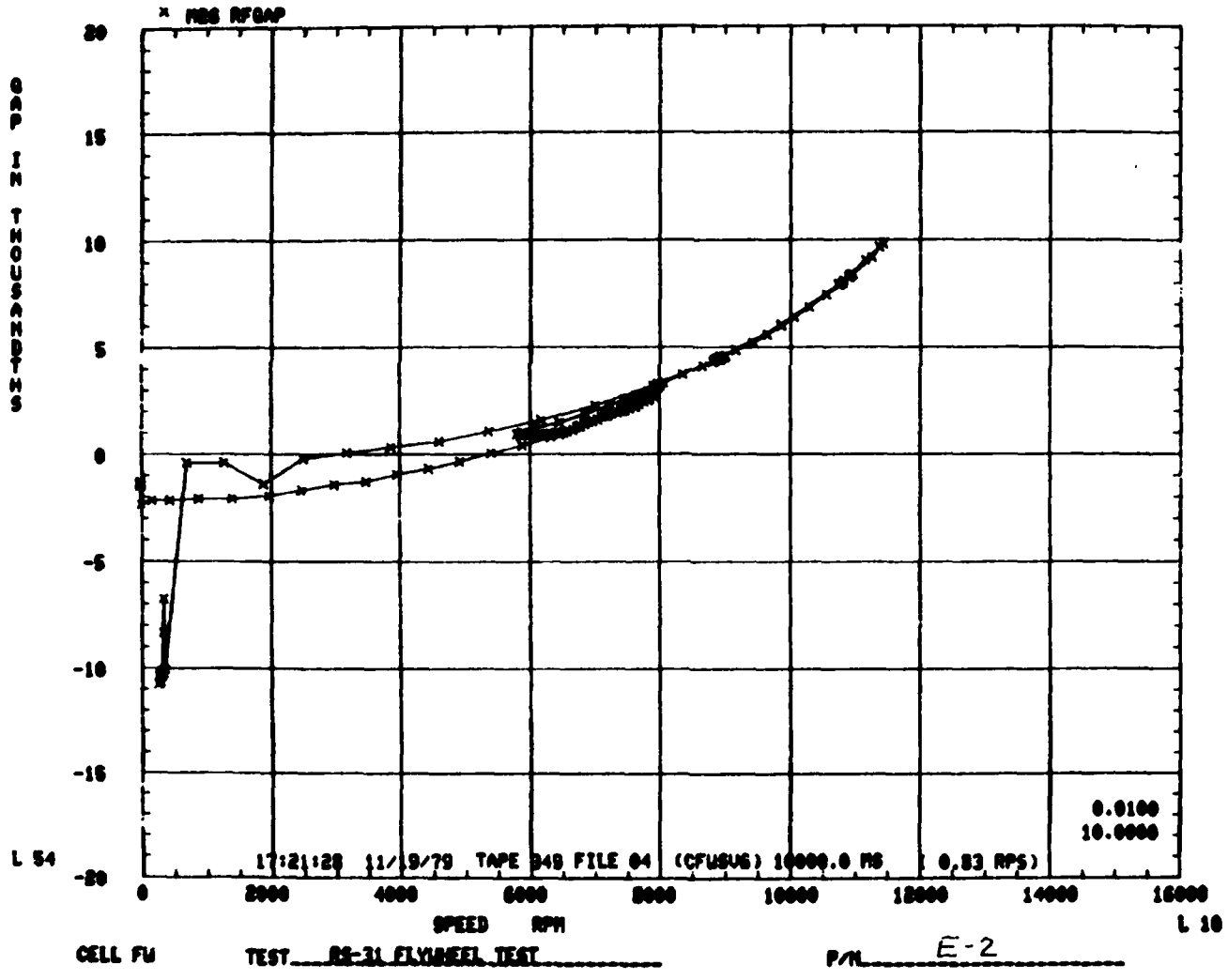


CELL FU TEST RS-31 FLYWHEEL TEST P/N E-2

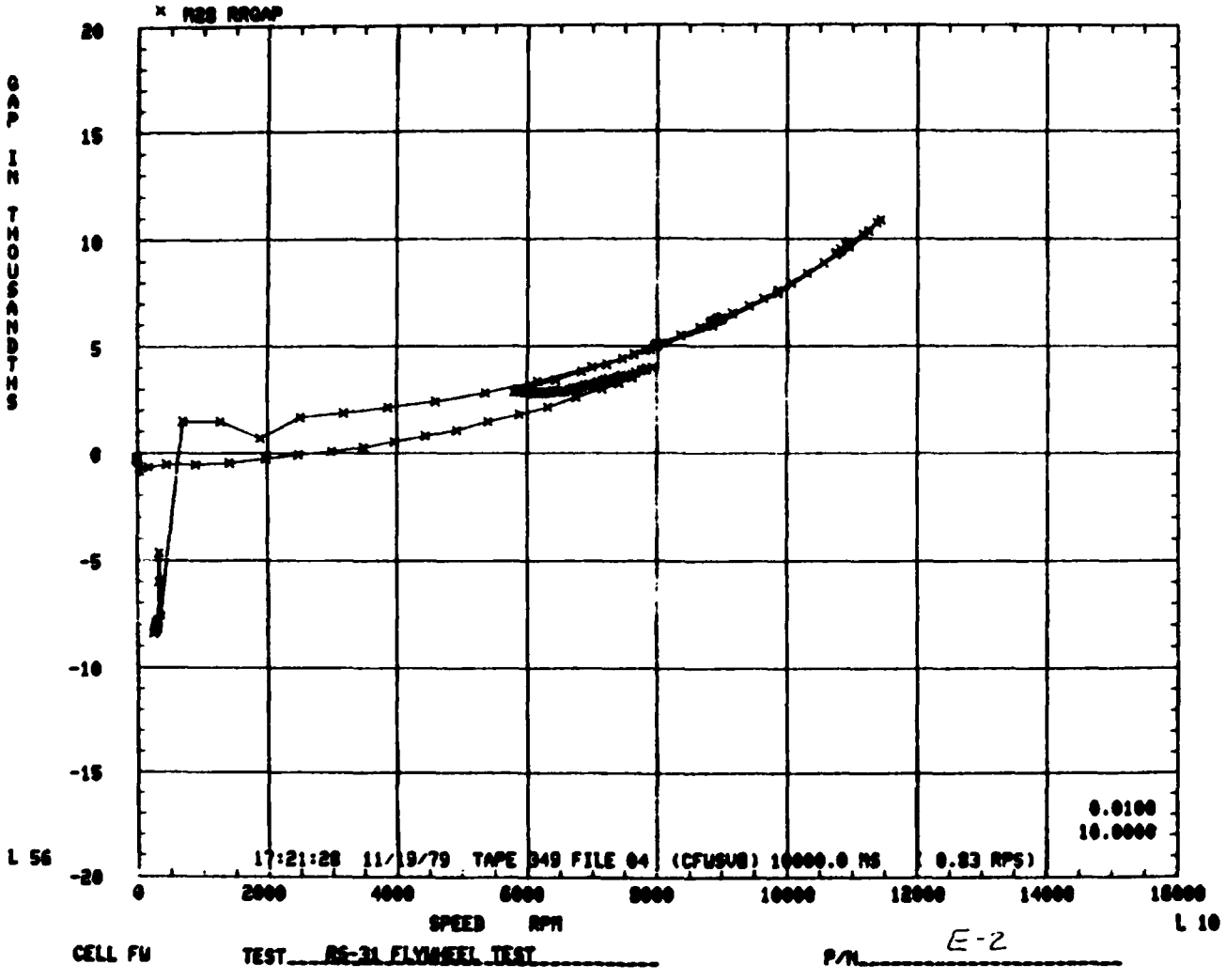


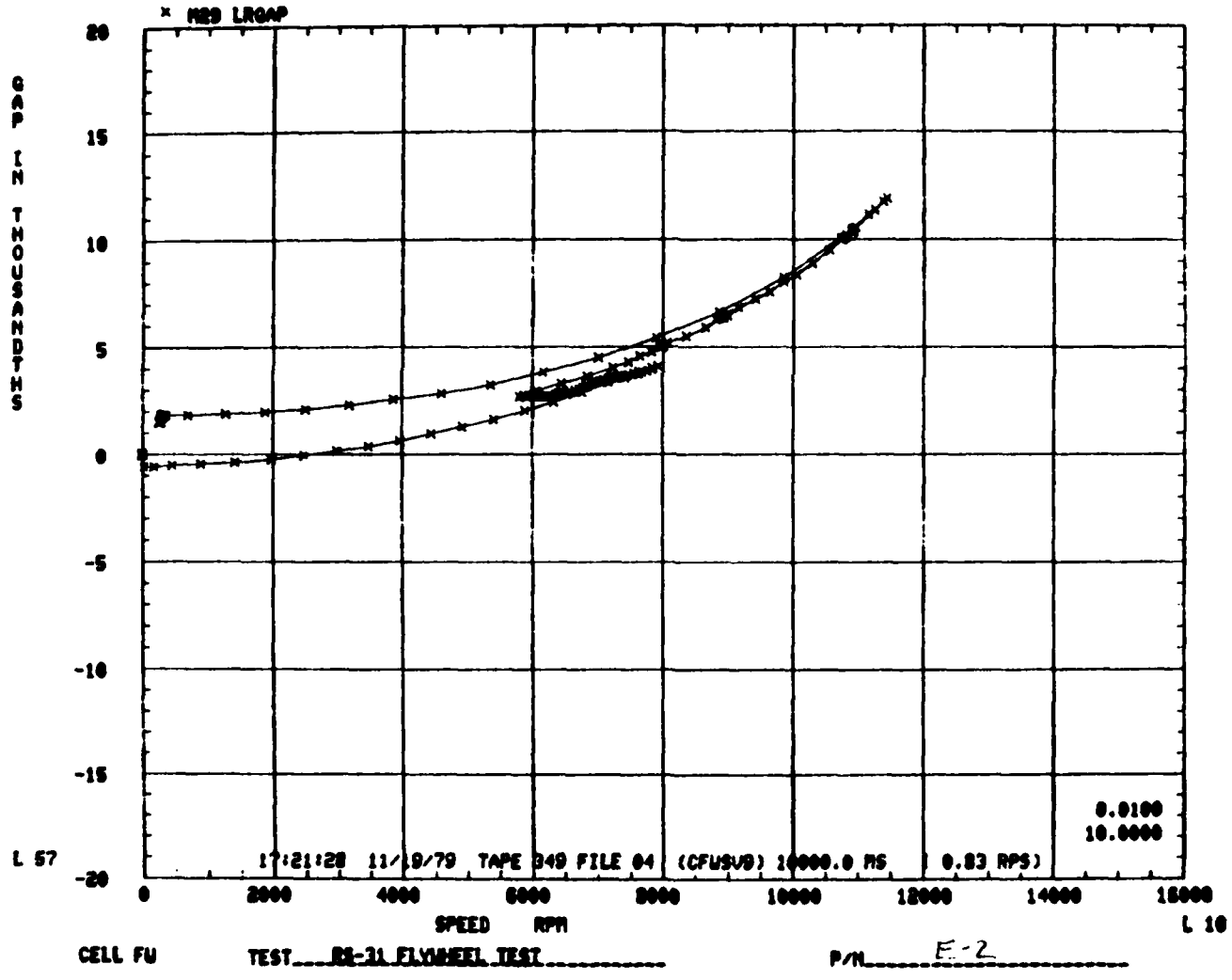
CELL FU TEST RS-21 FLYWHEEL TEST P/N E-2.

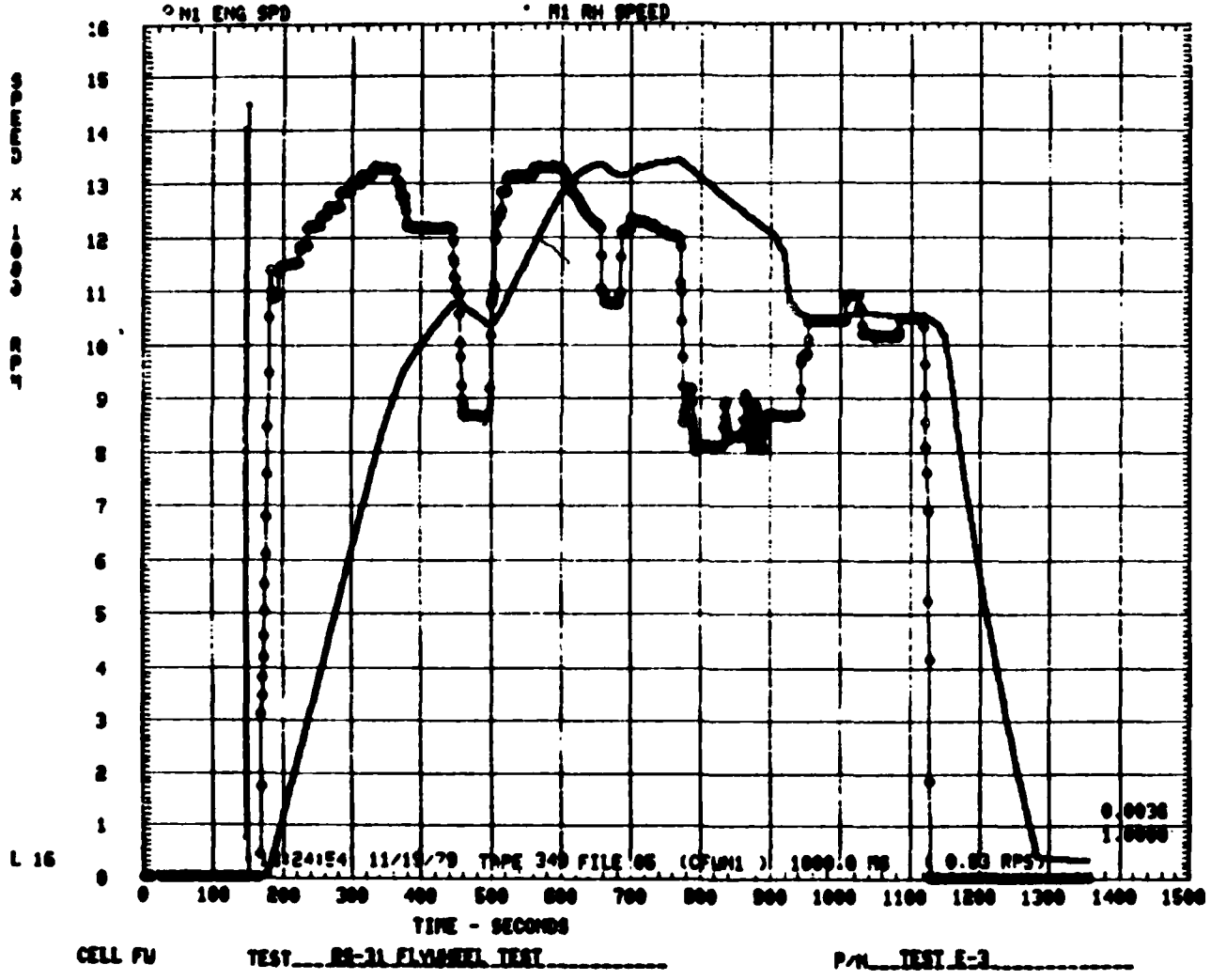

× RBS LRGAP
GAP IN THOUSANDTHS
20
15
10
5
0
-5
-10
-15
-20
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
TIME - SECONDS
17:21:28 11/19/79 TAPE 349 FILE 04 (COLVRBS) 1000.0 MS (0.83 RPS)
0.0100
1.0000
L 57
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N E-2



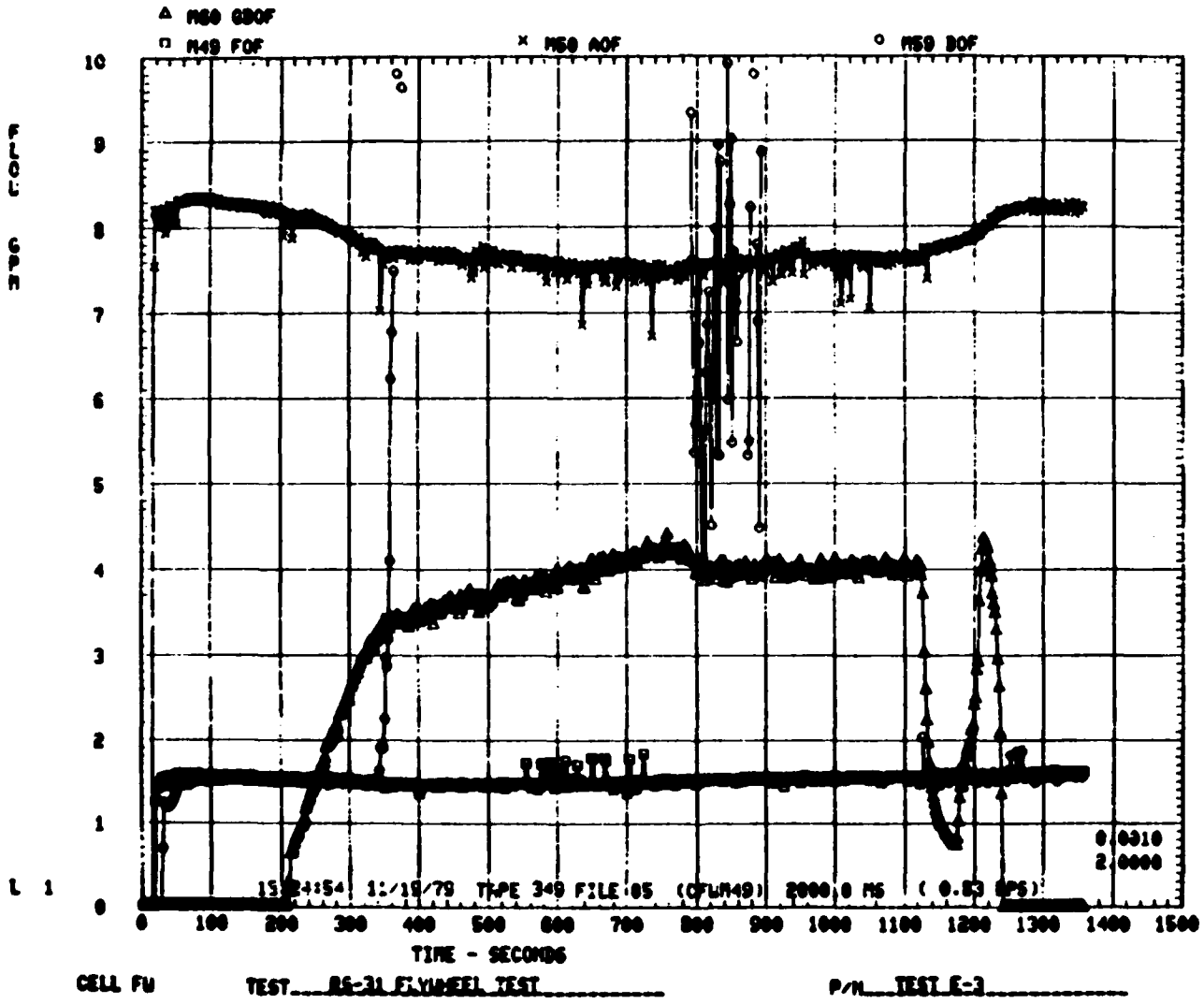
CELL FU TEST RS-31 FLYWHEEL TEST P/N E-2

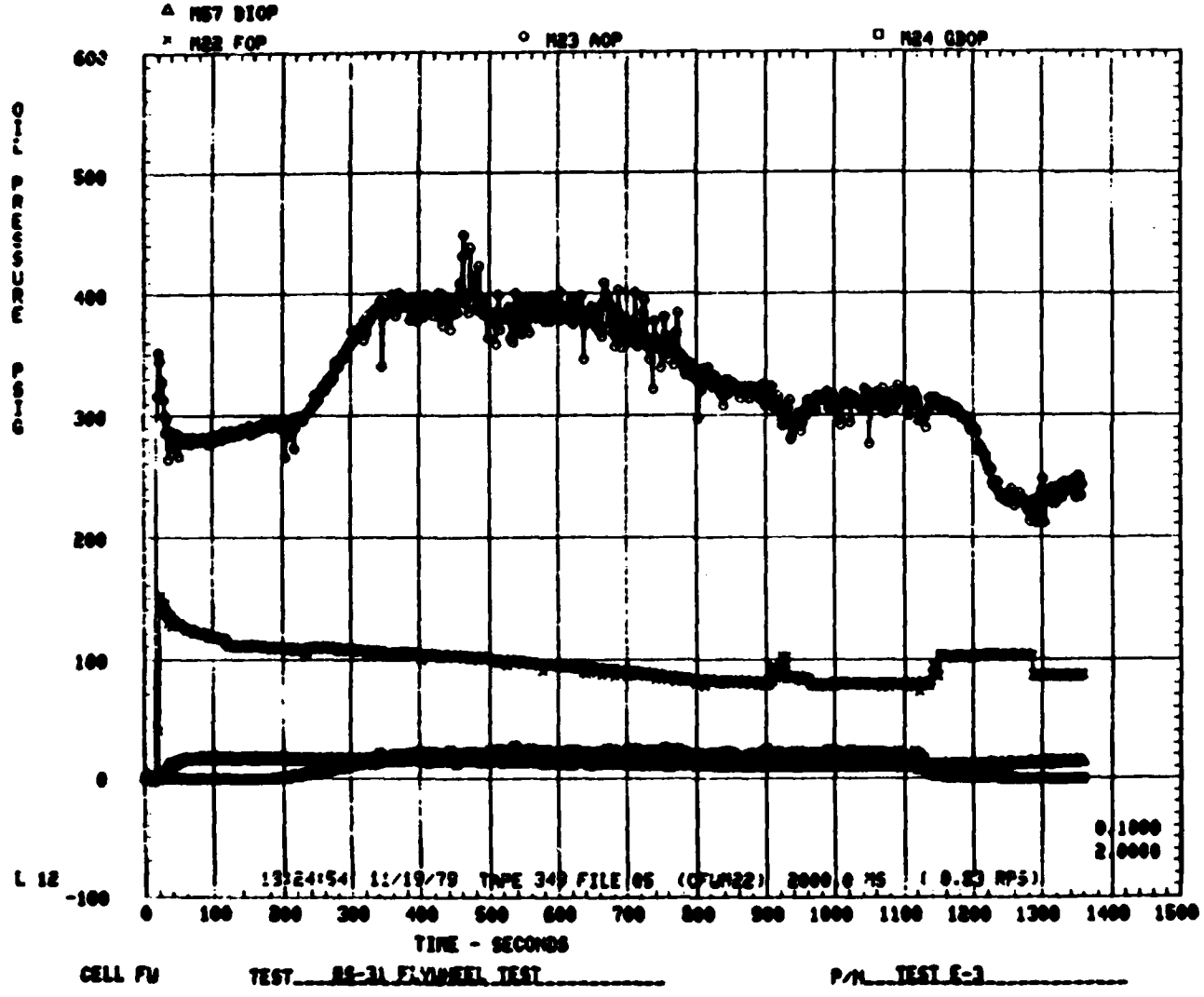

× N28 RROAP
GAP IN THOUSANDTHS
20
15
10
5
0
-5
-10
-15
-20
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
0.0100
10.0000
17:21:28 11/19/79 TAPE 949 FILE 04 (CFUSUB) 10000.0 RS (0.83 RPS)
L 56
L 10
CELL FW
TEST RS-31 FLYWHEEL TEST
P/N E-2

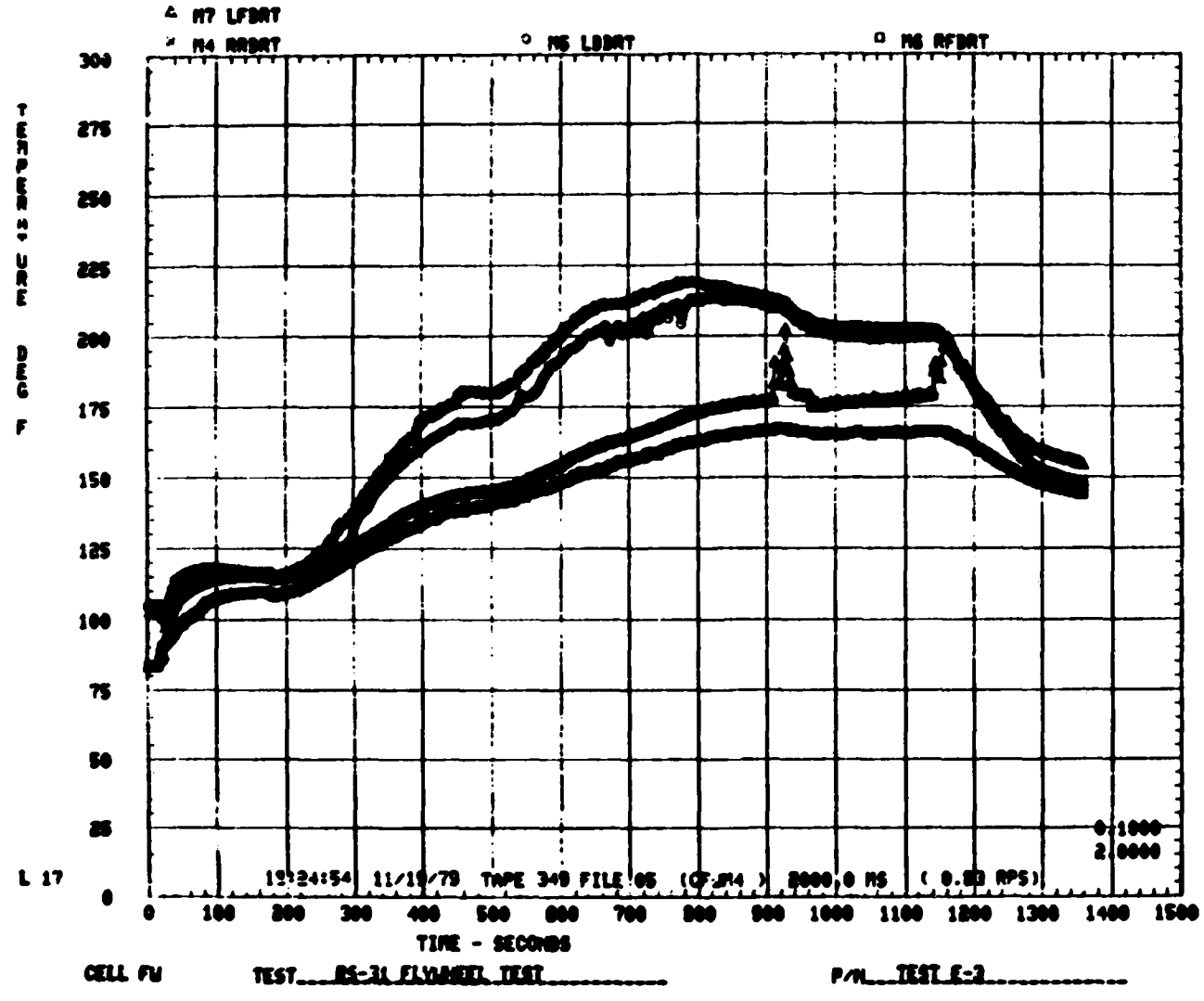

× M29 LROAP
GAP IN THOUSANDTHS
20
15
10
5
0
-5
-10
-15
-20
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
0.0100
10.0000
17:21:28 11/19/79 TAPE 349 FILE 04 (CFUSUB) 10000.0 RS 0.83 RPS)
L 57
L 10
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N E-2

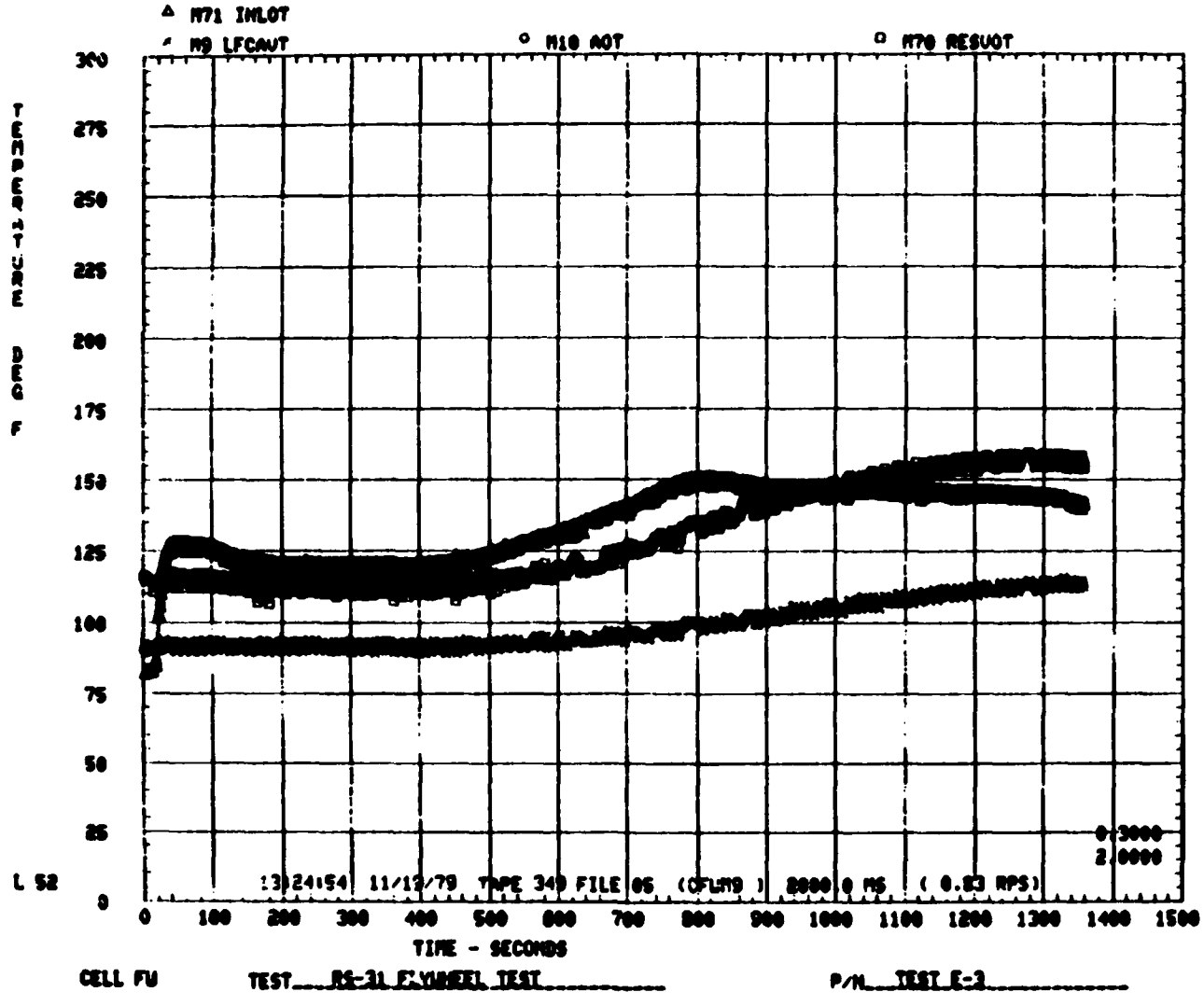


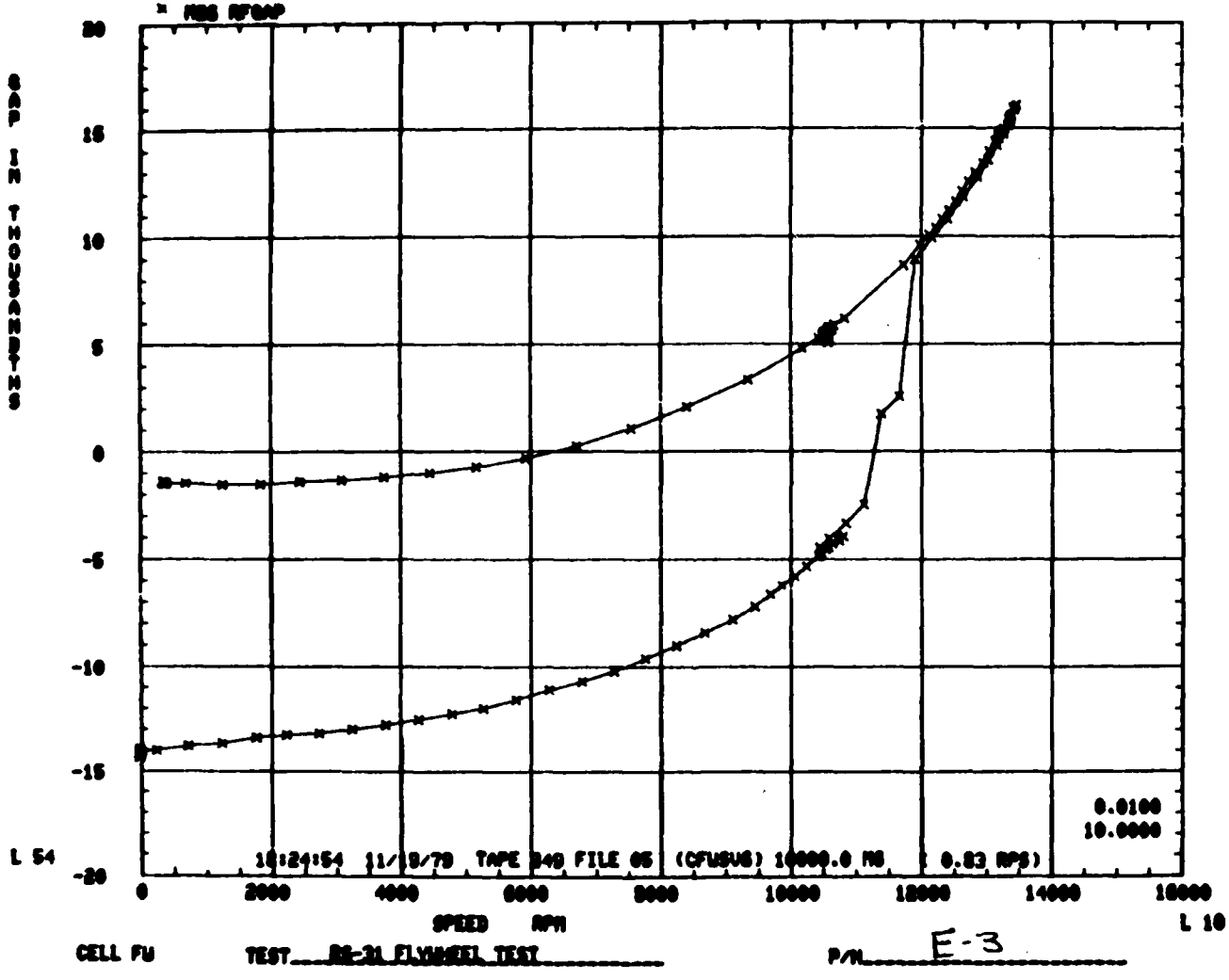
CELL FU TEST RS-31 FLYWHEEL TEST P/N TEST E-3

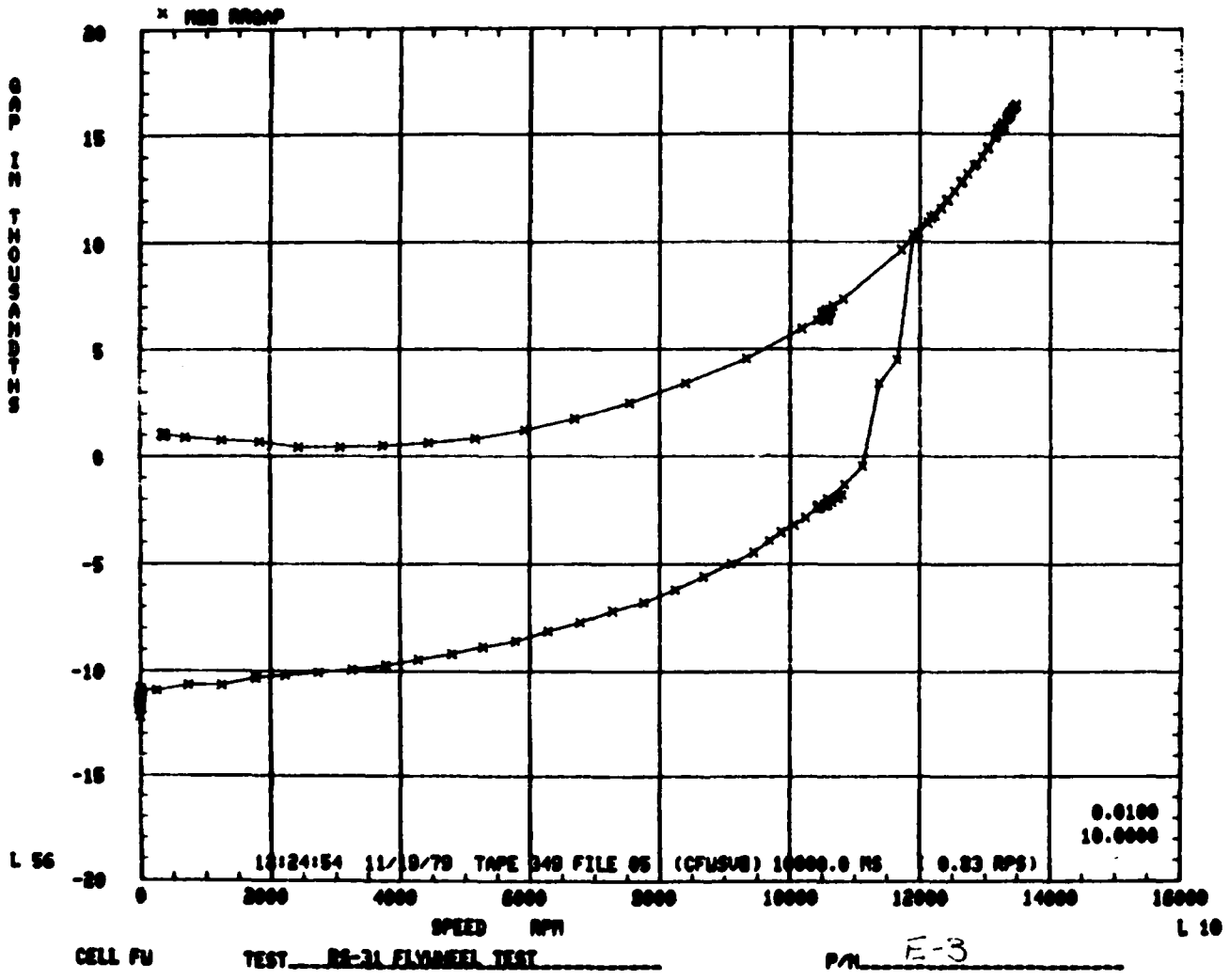

△ M80 GBOF
□ M49 FOF
× M50 AOF
○ M59 BOF
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TIME - SECONDS
0.0310
2.0000
15:24:54 1:/19/79 TAPE 349 FILE 05 (CFLM49) 2000.0 MS (0.03 SPS)
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST E-3

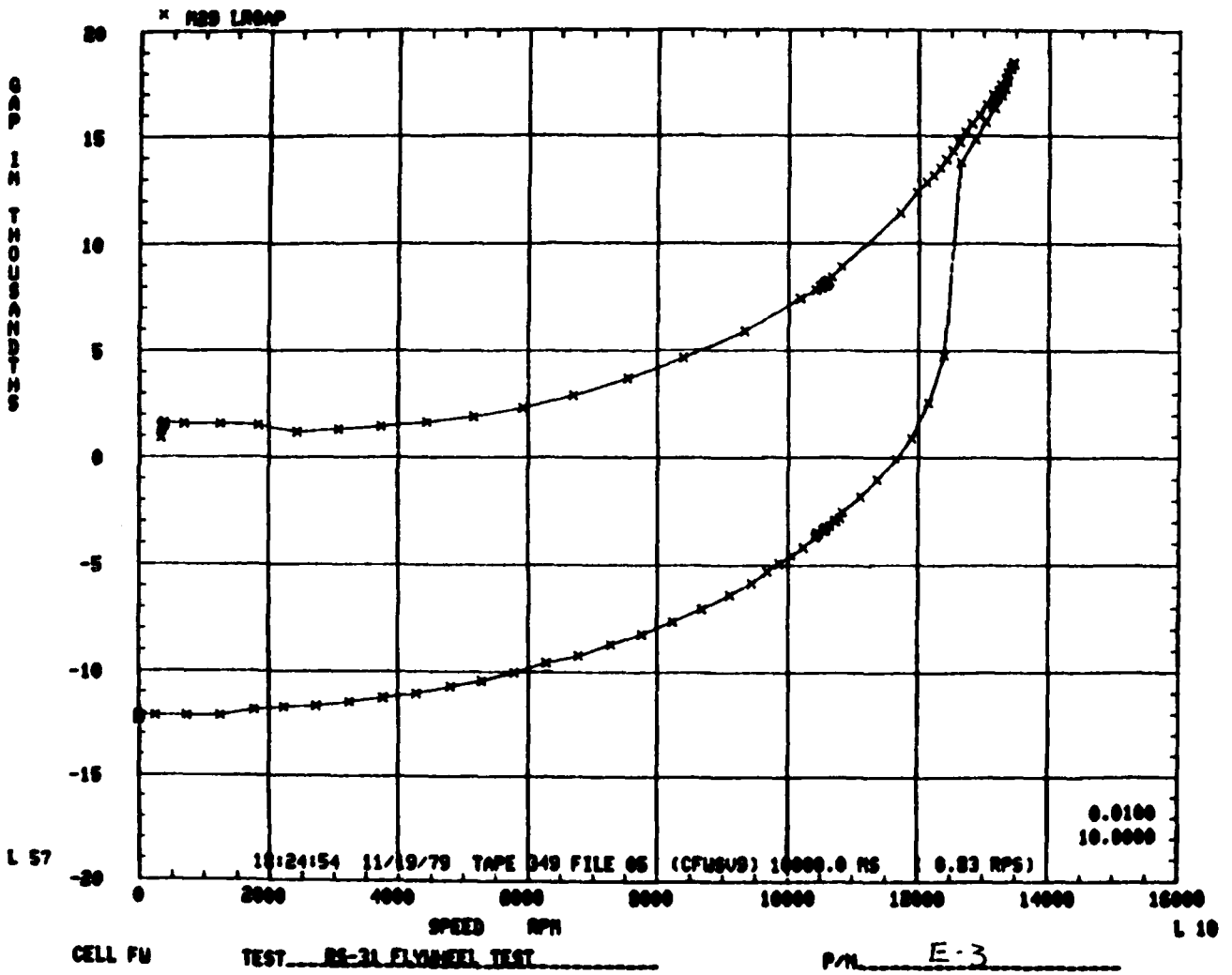

M57 DIOP
M22 FOP
M23 AOP
M24 GDOP
600
500
400
300
200
100
0
-100
0.1000
2.0000
13:24:54 11/19/79 TAPE 349 FILE 05 (CFUN22) 2000.0 MS (0.83 RPS)
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
TIME - SECONDS
L 12
CELL FU
TEST 88-31 FLYWHEEL TEST
P/N TEST E-3

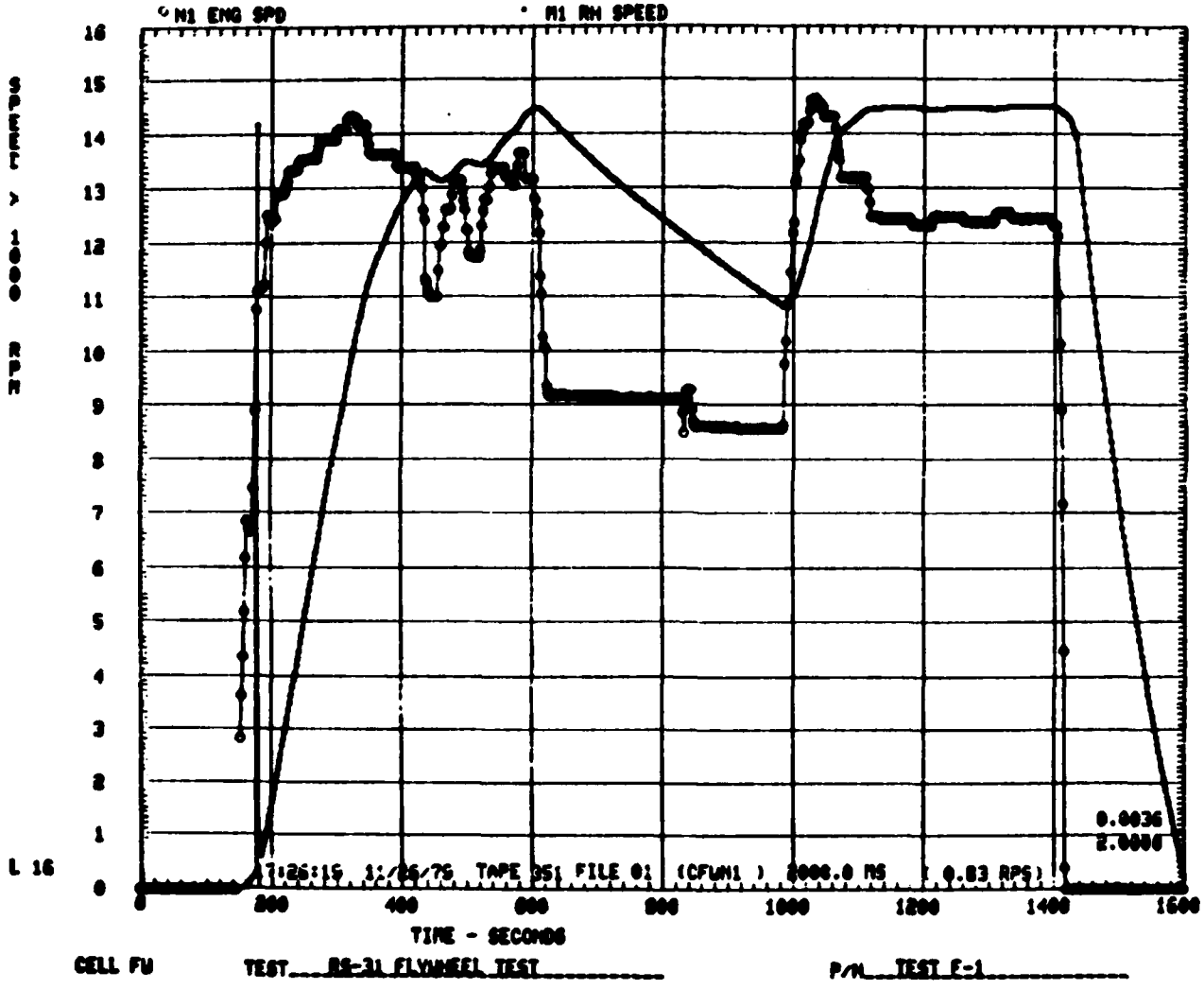

M7 LFBRT
M4 RRBRT
M5 LBBRT
M6 RFBRT
TEMPERATURE DEG F
300
275
250
225
200
175
150
125
100
75
50
25
0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TIME - SECONDS
L 17
0:1000
2:0000
CELL FW
TEST RS-31 FLYWHEEL TEST
P/N TEST E-2

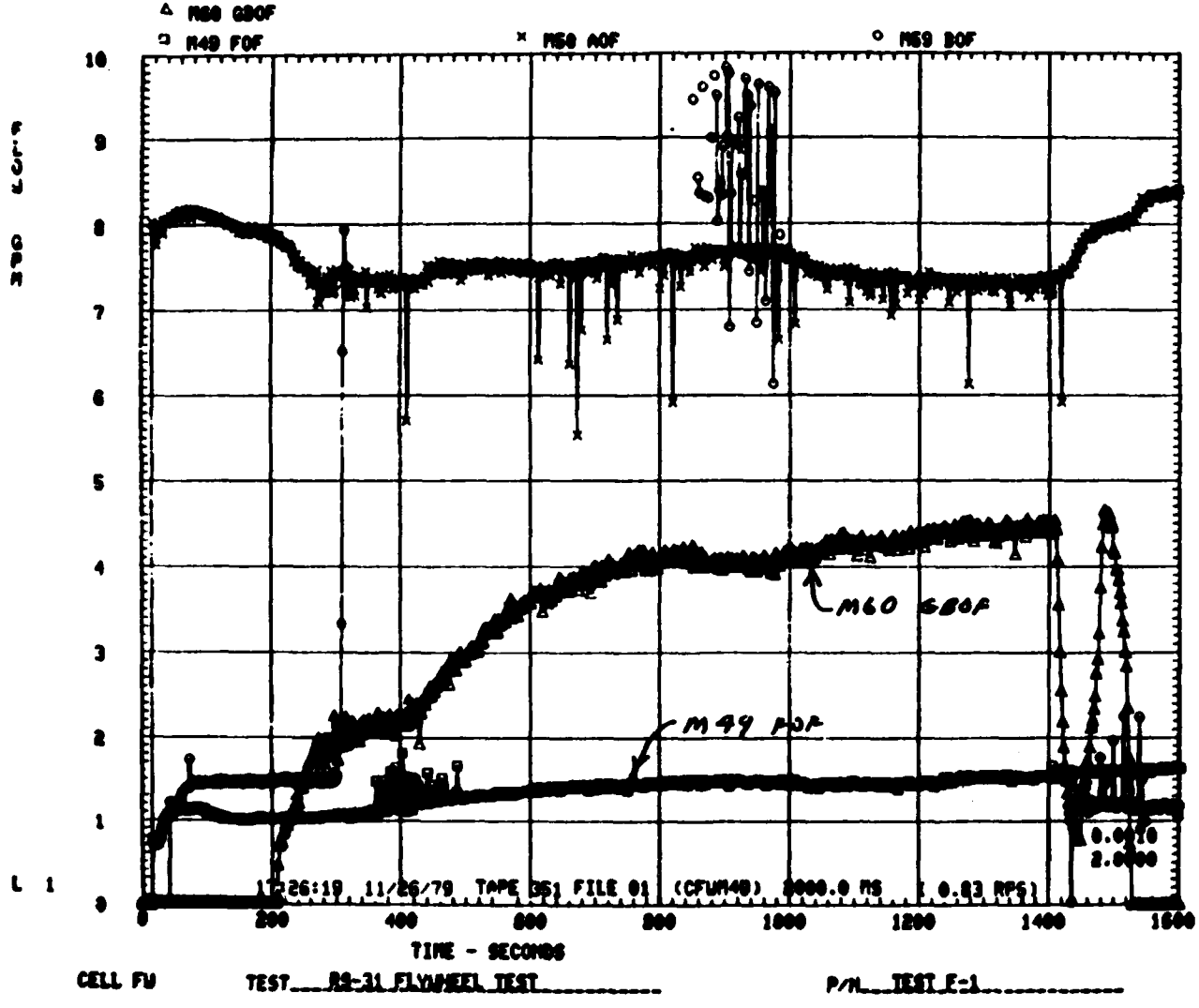

△ M71 INLOT
◇ M9 LFCAUT
○ M10 AOT
□ M70 RESUOT
TEMPERATURE DEG F
300
275
250
225
200
175
150
125
100
75
50
25
0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TIME - SECONDS
0.3000
2.0000
L 52
13:24:54 11/12/79 TAPE 349 FILE 06 (CFLM9) 8000.0 MS (0.83 RPS)
CELL FU
TEST RS-31 F.WHEEL TEST
P/N TEST E-3

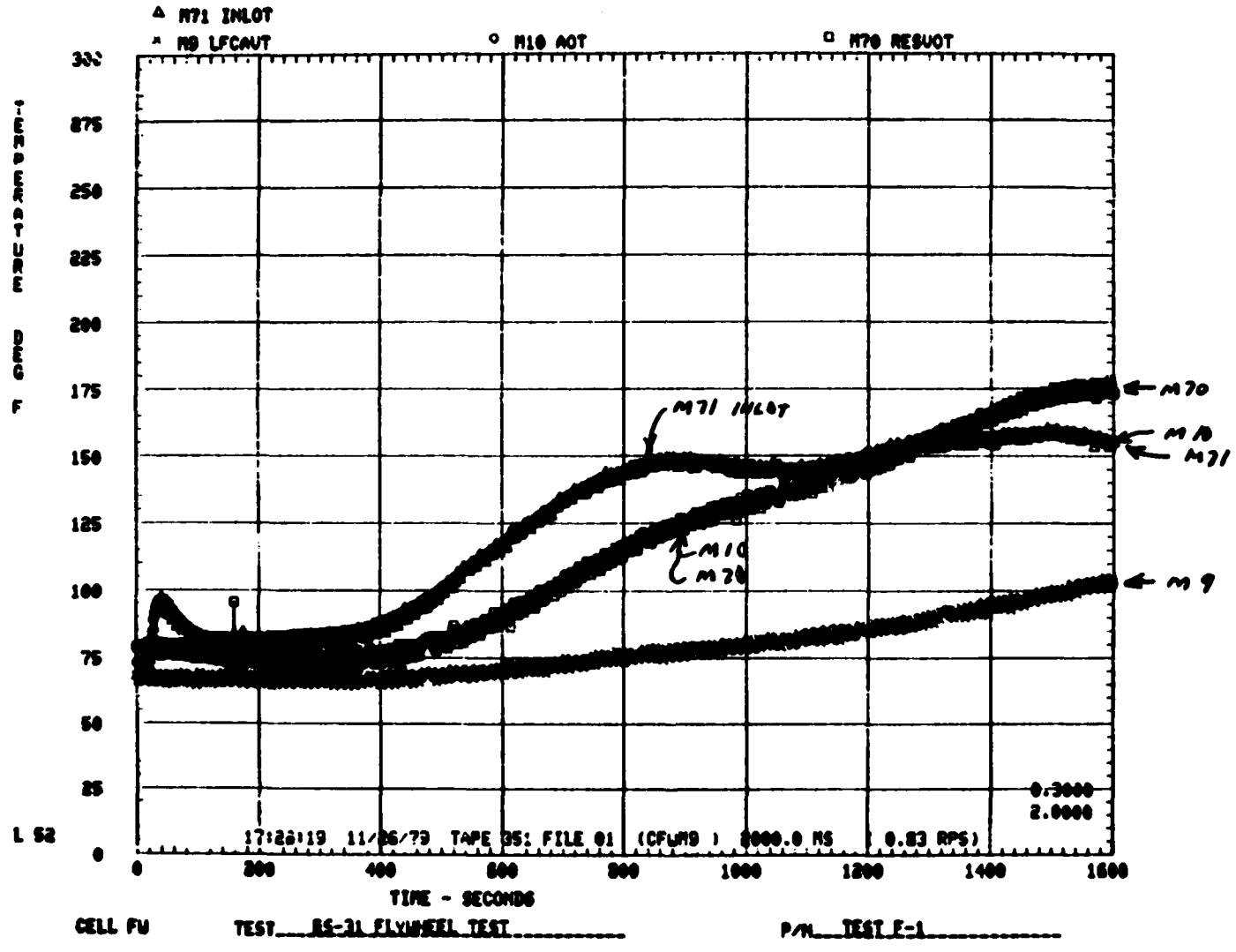

* MRS RPSAP
GAP IN THOUSANDTHS
20
15
10
5
0
-5
-10
-15
-20
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
L 54
L 10
0.0100
10.0000
15:24:54 11/19/79 TAPE 340 FILE 05 (CFUSUS) 10000.0 MS (0.83 RPS)
CELL FU
TEST RR-31 FLYWHEEL TEST
P/N E-3

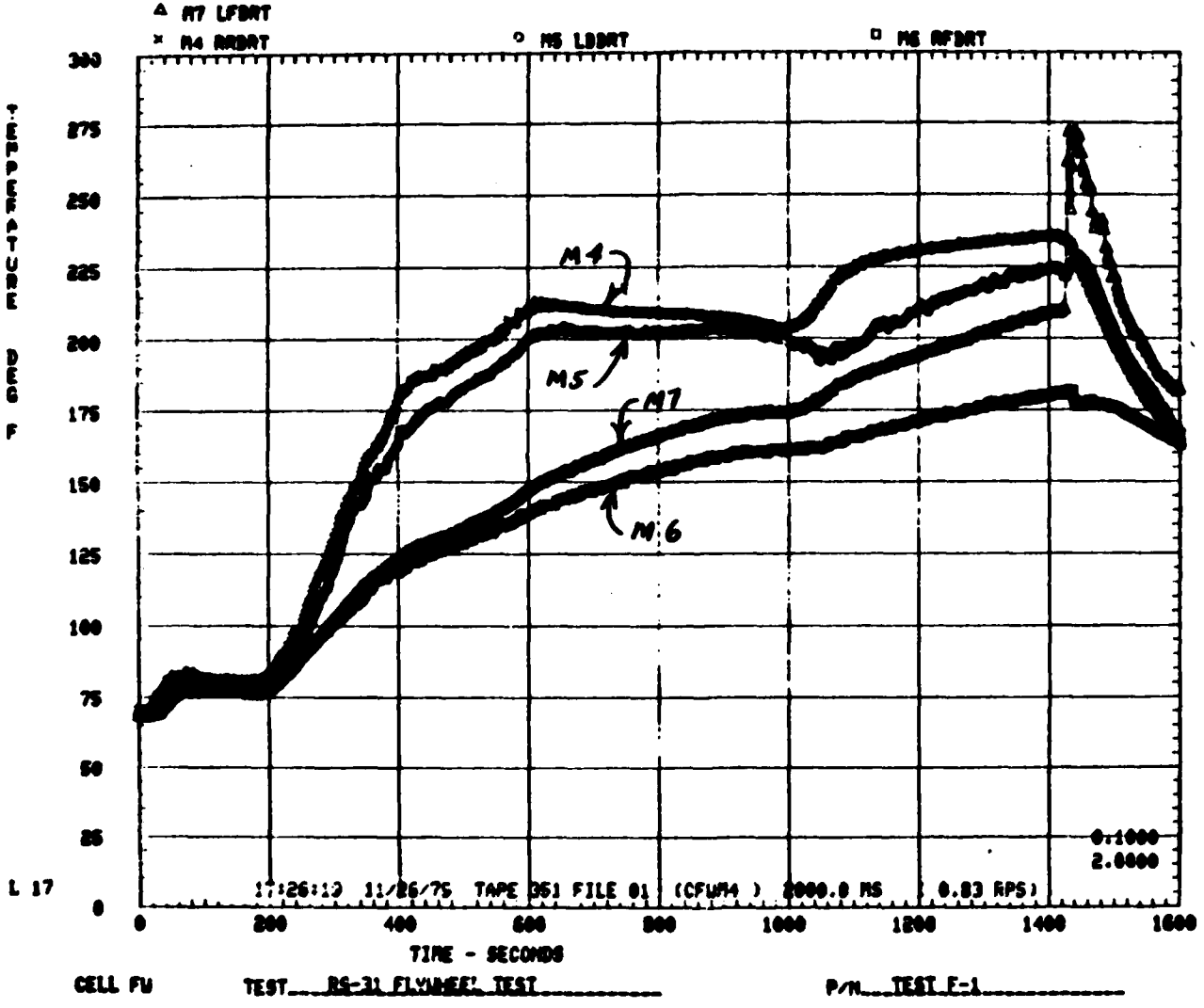

X RUB ROOP
GAP IN THOUSANDTHS
20
15
10
5
0
-5
-10
-15
-20
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
0.0100
10.0000
12:24:54 11/19/79 TAPE 249 FILE 05 (CFUSUB) 10000.0 RS (0.83 RPS)
L 56
L 10
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N E-3

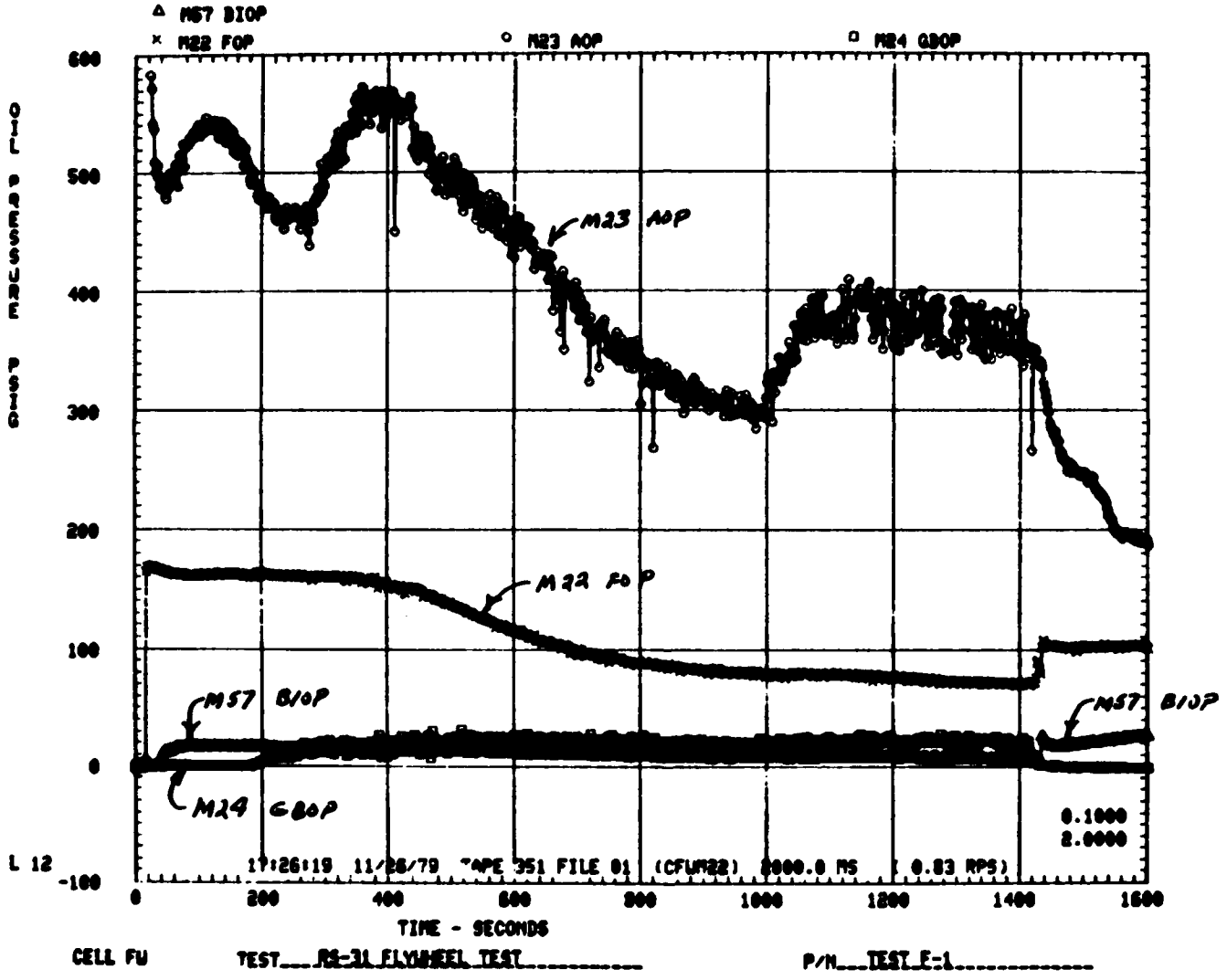

× RSS LRGAP
GAP IN THOUSANDTHS
20
15
10
5
0
-5
-10
-15
-20
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
L 10
L 57
0.0100
10.0000
10:24:54 11/19/79 TAPE 049 FILE 05 (CFUSUS) 10000.0 MS 0.83 RPS)
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N E-3

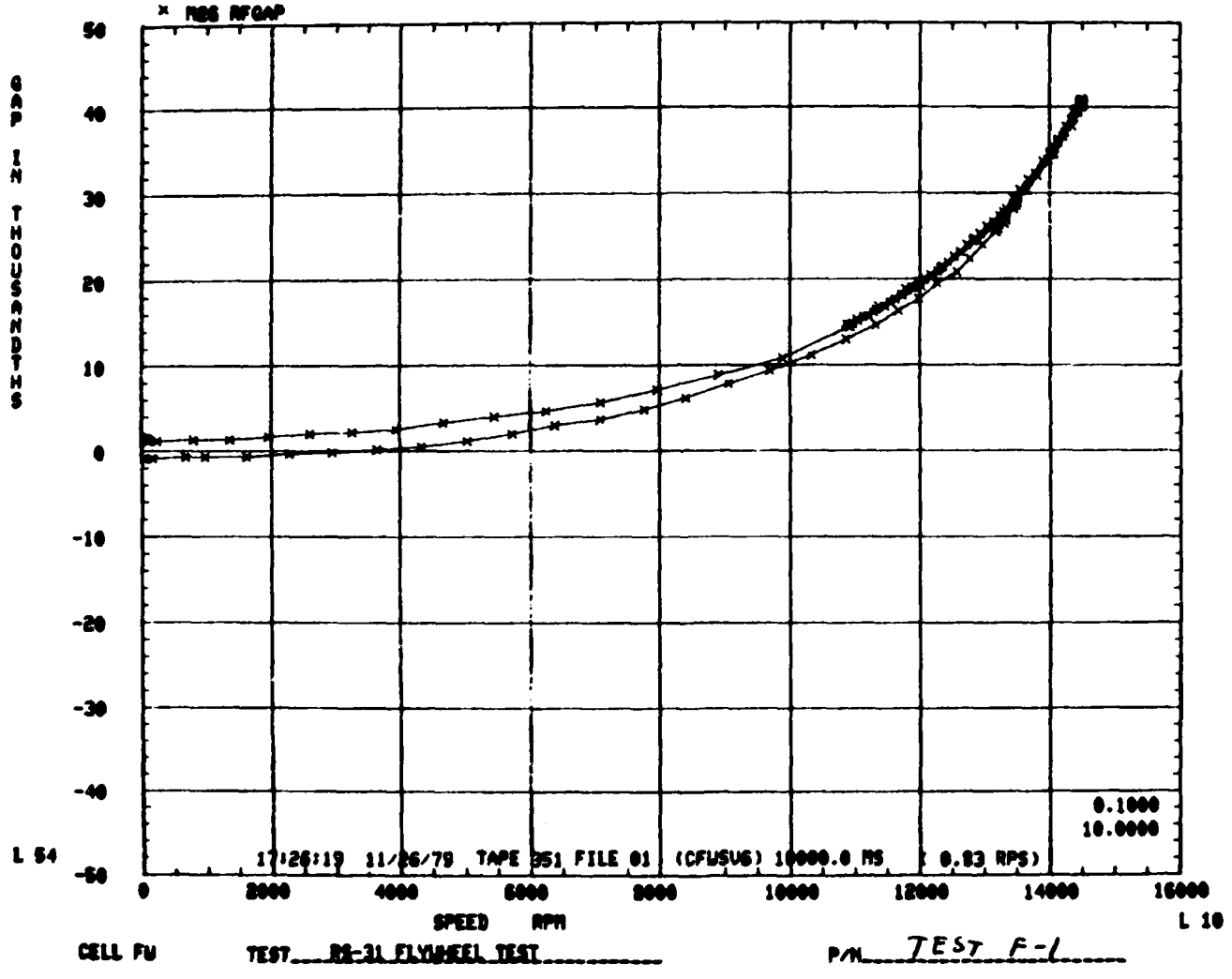

M1 ENG SPD
M1 RH SPEED
SPEED x 1000 RPM
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
TIME - SECONDS
0.0036
2.0000
7:26:15 1/26/75 TAPE 35 FILE 01 (CFLN1) 2000.0 MS (0.83 RPS)
L 16
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-1

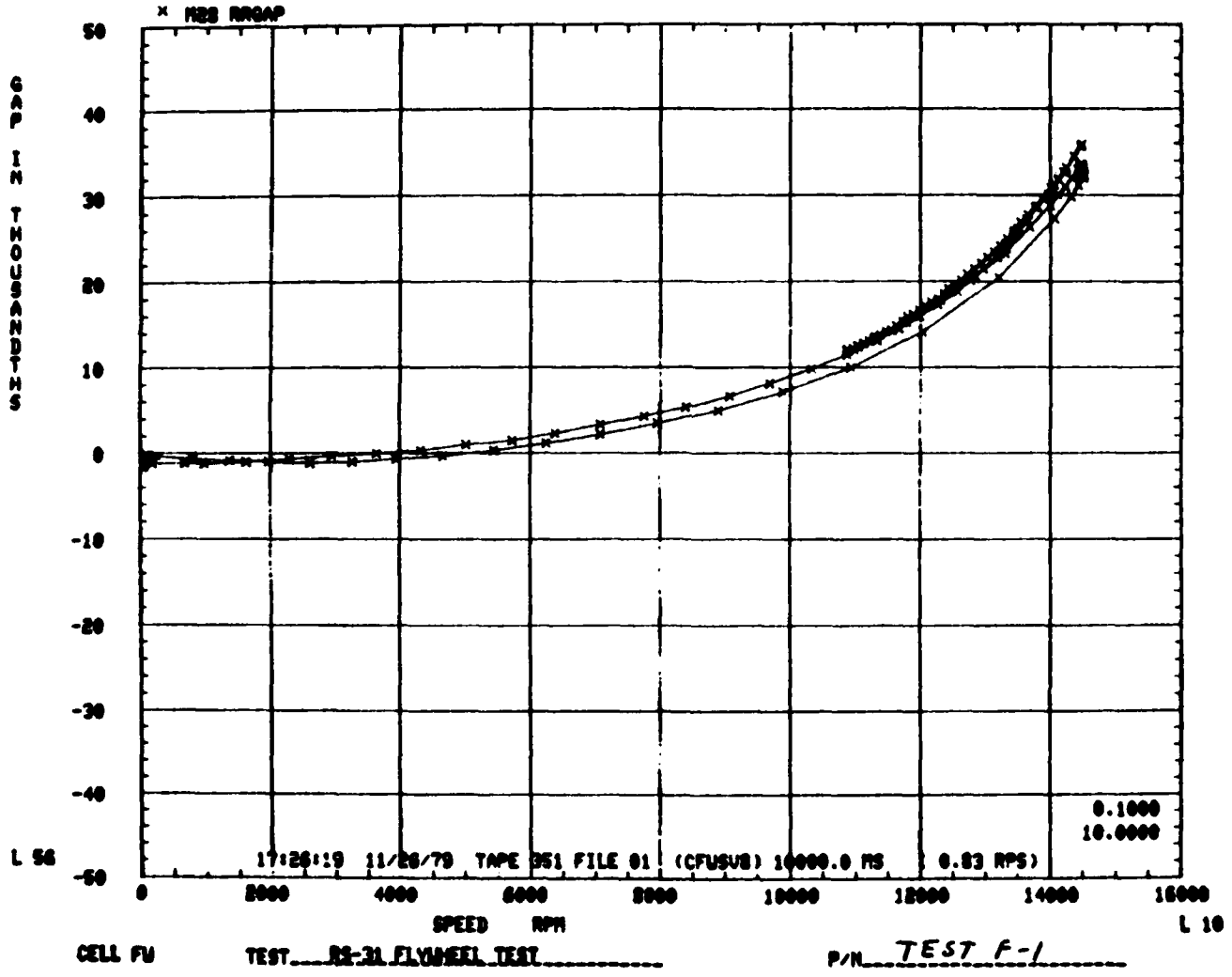

M60 GBOF
M49 FOF
M60 AOF
M59 BOF
M60 GBOF
M49 FOF
TIME - SECONDS
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-1

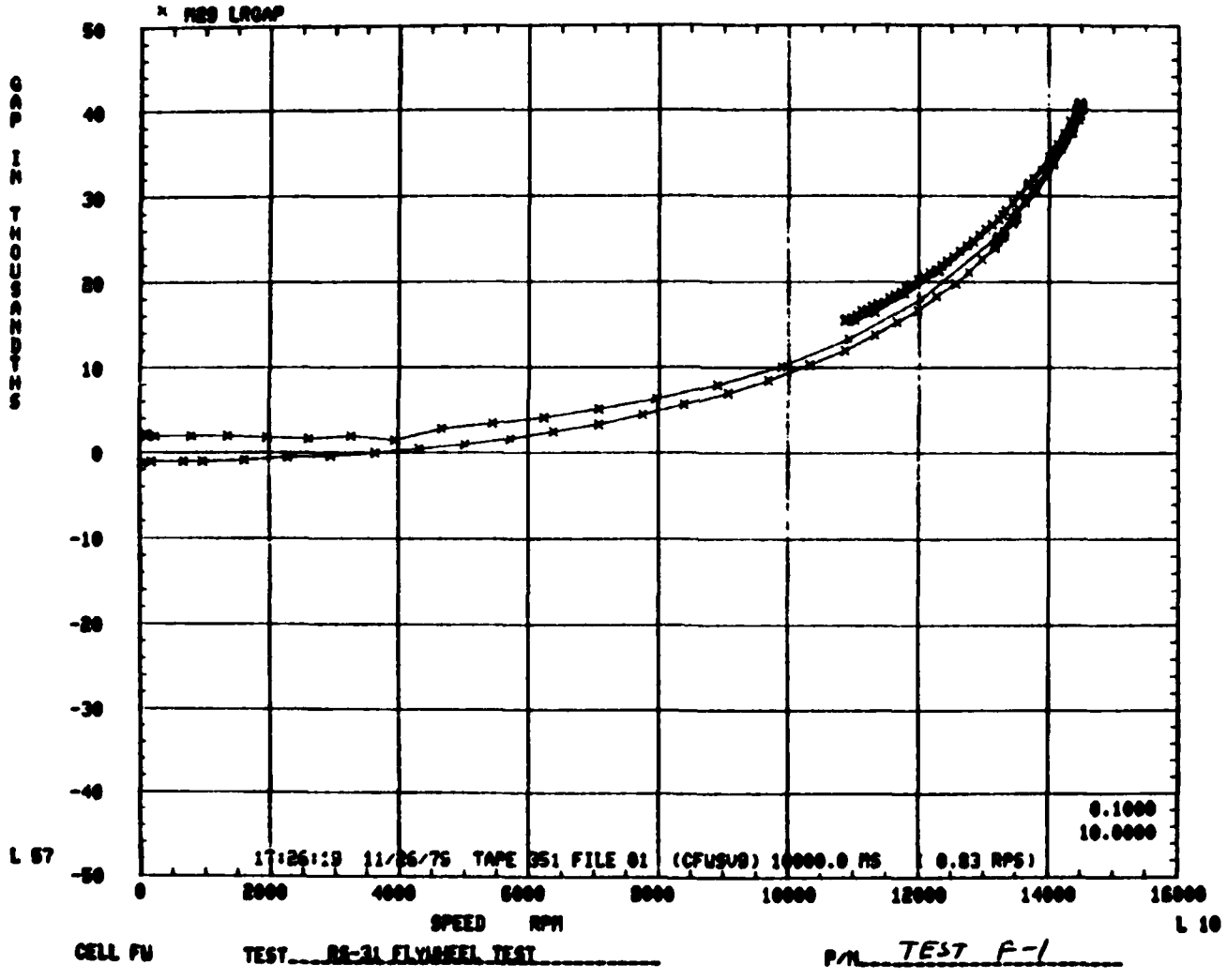

M71 INLOT
M9 LFCAUT
M10 AOT
M70 RESUOT
TEMPERATURE DEG F
875
250
225
200
175
150
125
100
75
50
25
0
0
200
400
600
800
1000
1200
1400
1600
TIME - SECONDS
M71 INLOT
M70
M9
M71
M10
M70
M9
0.3000
2.0000
17:28:19 11/26/79 TAPE 35: FILE 01 (CFLM9) 8000.0 MS 0.83 RPS)
L 52
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-1

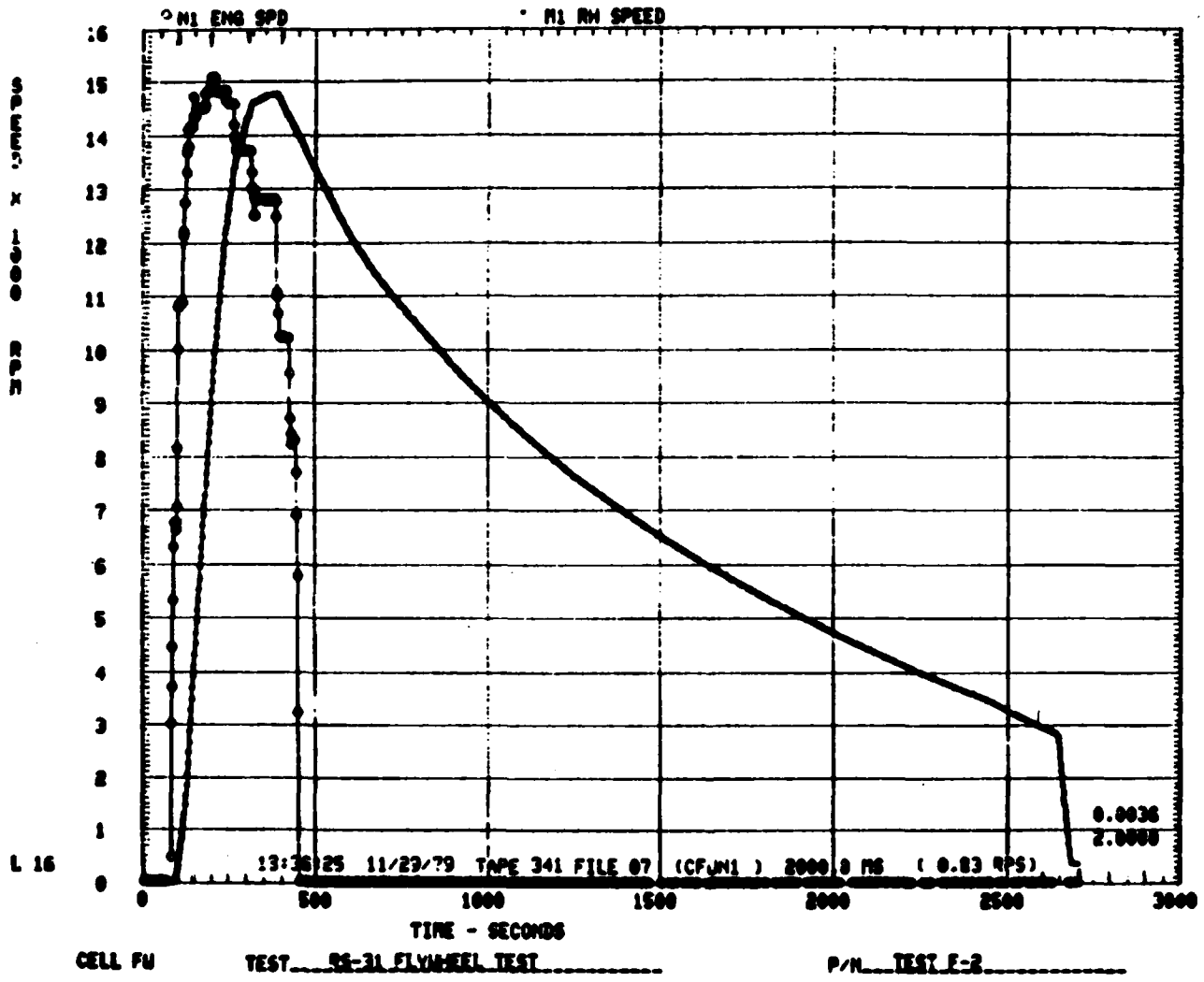

M7 LFBRT
M4 ARBRT
M5 LBBRT
M6 RFBRT
TEMPERATURE DEG F
300
275
250
225
200
175
150
125
100
75
50
25
0
M4
M5
M7
M6
0.1000
2.0000
L 17
17:26:12 11/26/75 TAPE 351 FILE 01 (CFUM4) 2000.0 MS (0.83 RPS)
0
200
400
600
800
1000
1200
1400
1600
TIME - SECONDS
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-1

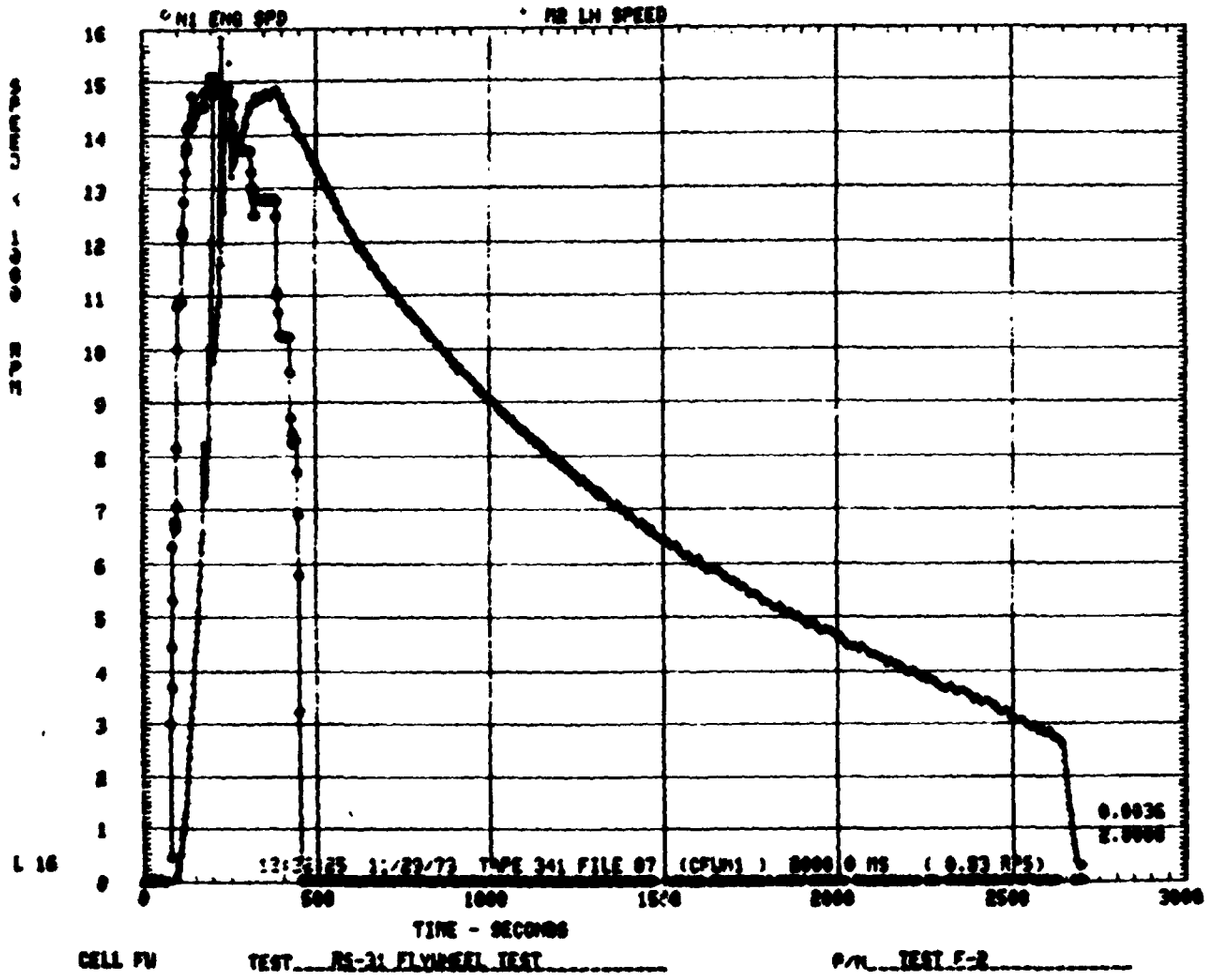

M57 BIOP
M22 FOP
M23 AOP
M24 GBOP
OIL PRESSURE PSIG
600
500
400
300
200
100
0
-100
M23 AOP
M22 FOP
M57 BIOP
M57 BIOP
M24 GBOP
0.1000
2.0000
L 12
17:26:19 11/28/79 TAPE 351 FILE 01 (CFUM22) 2000.0 MS (0.83 RPS)
0
200
400
600
800
1000
1200
1400
1600
TIME - SECONDS
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-1


× RBS RFGAP
GAP IN THOUSANDTHS
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
L 54
L 10
0.1000
10.0000
17:26:19 11/26/79 TAPE 351 FILE 01 (CFUSUB) 10000.0 MS (0.83 RPS)
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-1

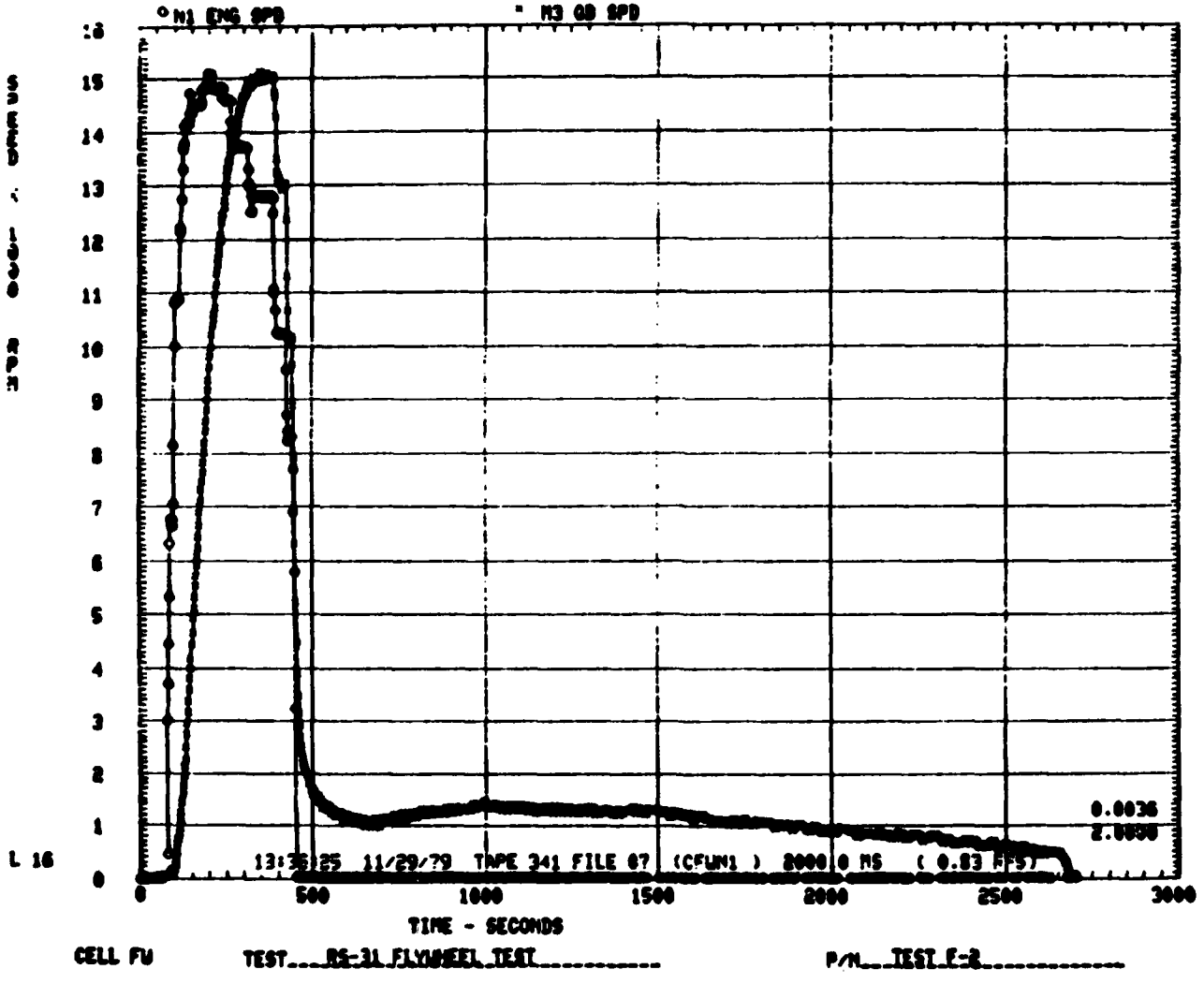

× M28 RRGAP
GAP IN THOUSANDTHS
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
0.1000
10.0000
17:26:19 11/26/79 TAPE 351 FILE 01 (CFUSUB) 10000.0 MS 0.83 RPS)
L 56
L 10
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-1


X RED LROAP
GAP IN THOUSANDTHS
50
40
30
20
10
0
-10
-20
-30
-40
-50
0.1000
10.0000
17:26:18 11/26/75 TAPE 351 FILE 01 (CFUSU8) 10000.0 MS 0.83 RPS)
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
L 57
L 10
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-1

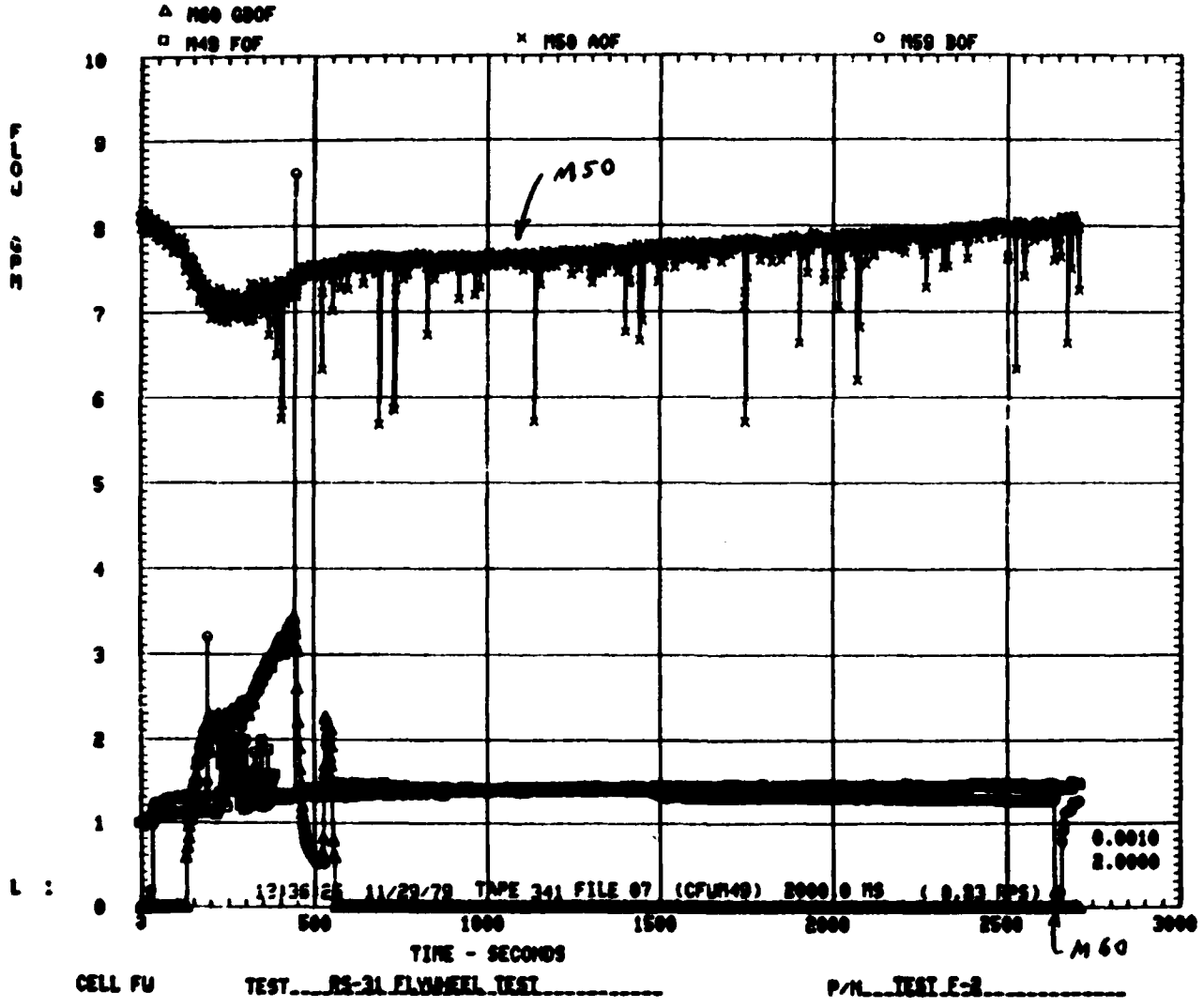

M1 ENG SPD
M1 RH SPEED
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
500
1000
1500
2000
2500
3000
TIME - SECONDS
0.0036
2.0000
13:36:25 11/29/79 TAPE 341 FILE 07 (CFJN1) 2000.0 MS (0.83 RPS)
L 16
CELL FW
TEST RS-31 FLYWHEEL TEST
P/N TEST F-2



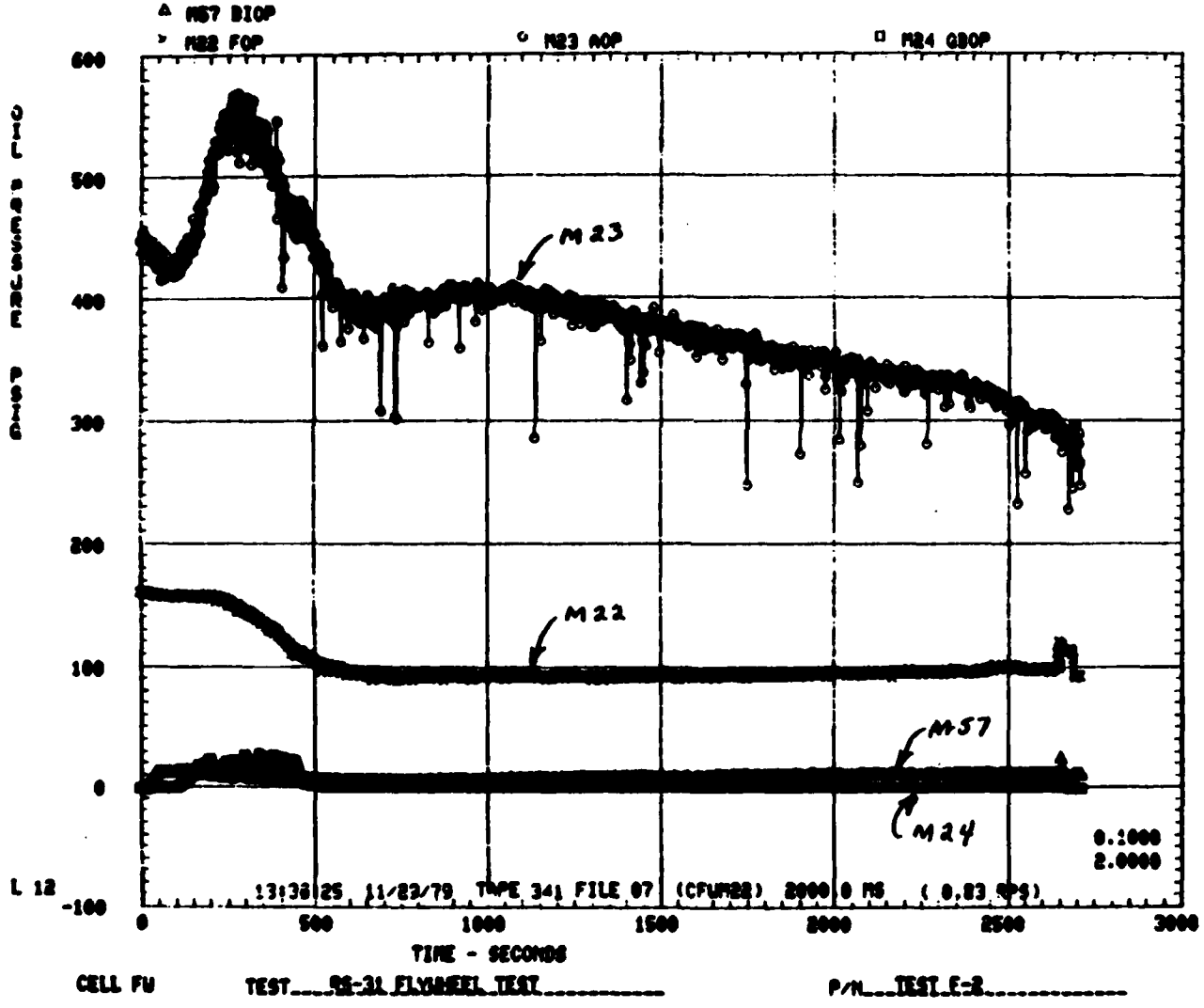
CELL FW TEST RS-31 FLYWHEEL TEST P/N TEST F-2

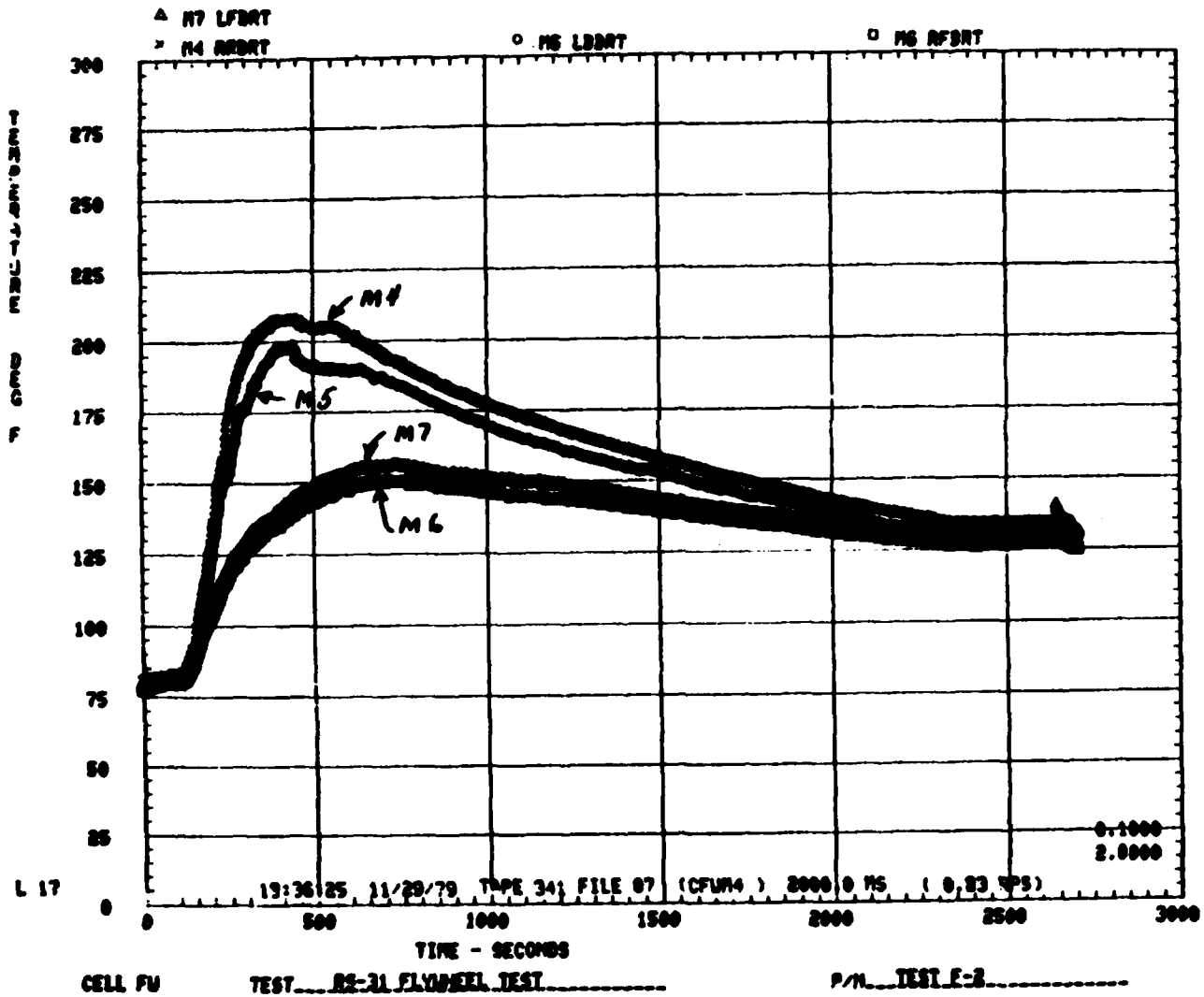


CELL FU TEST RS-31 FLYWHEEL TEST P/N TEST F-2

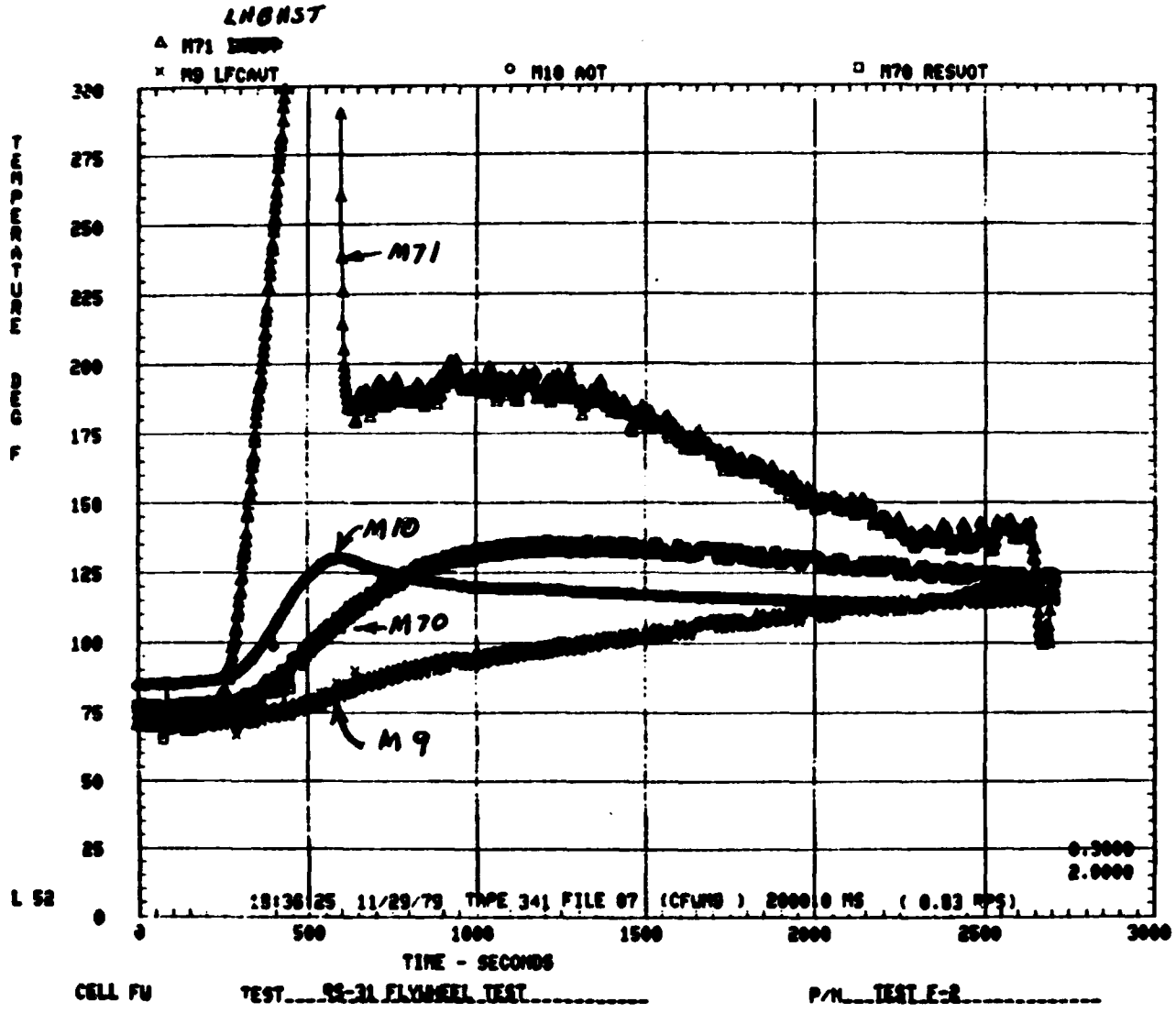


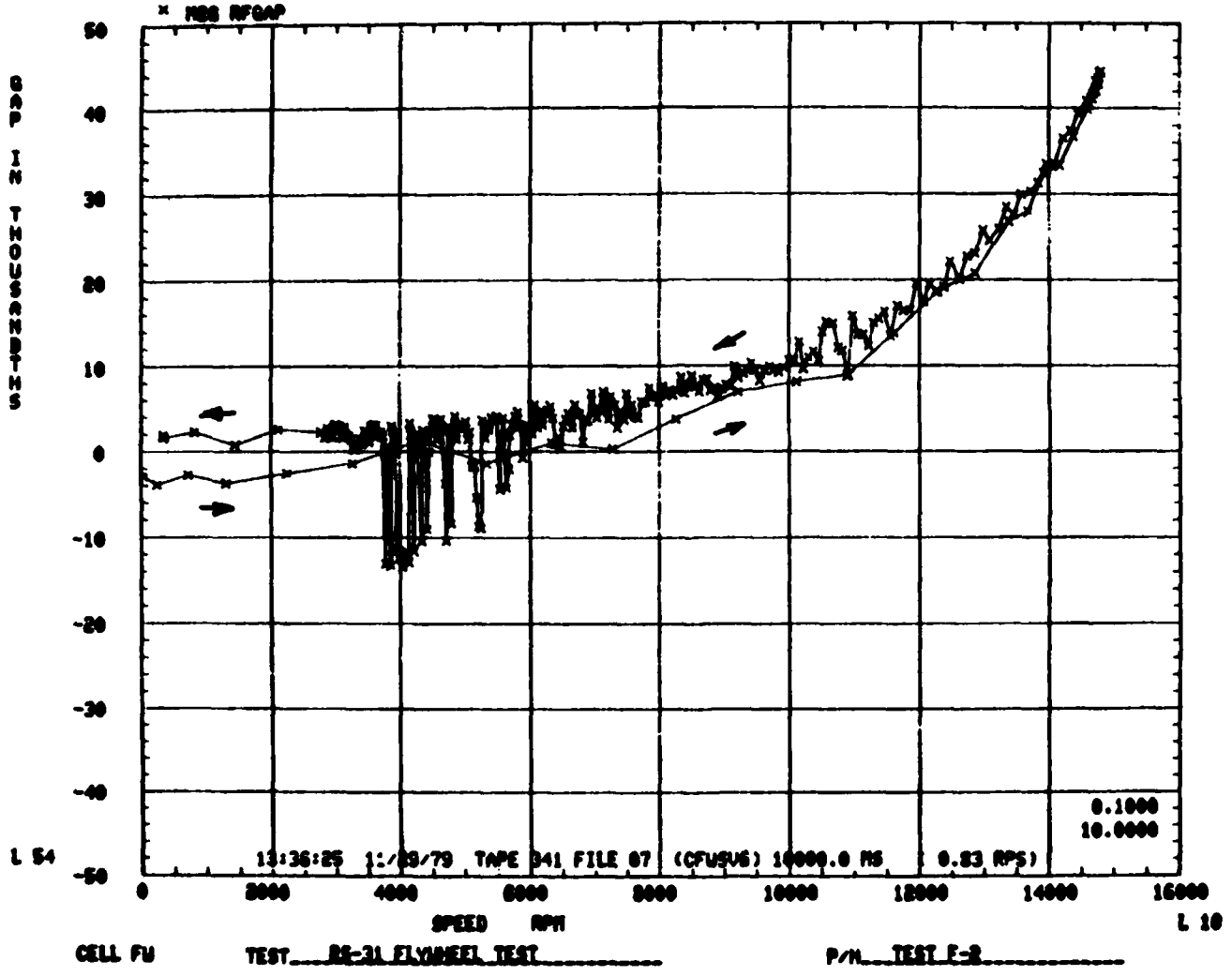
CELL FU TEST RS-31 FLYWHEEL TEST P/N TEST F-8

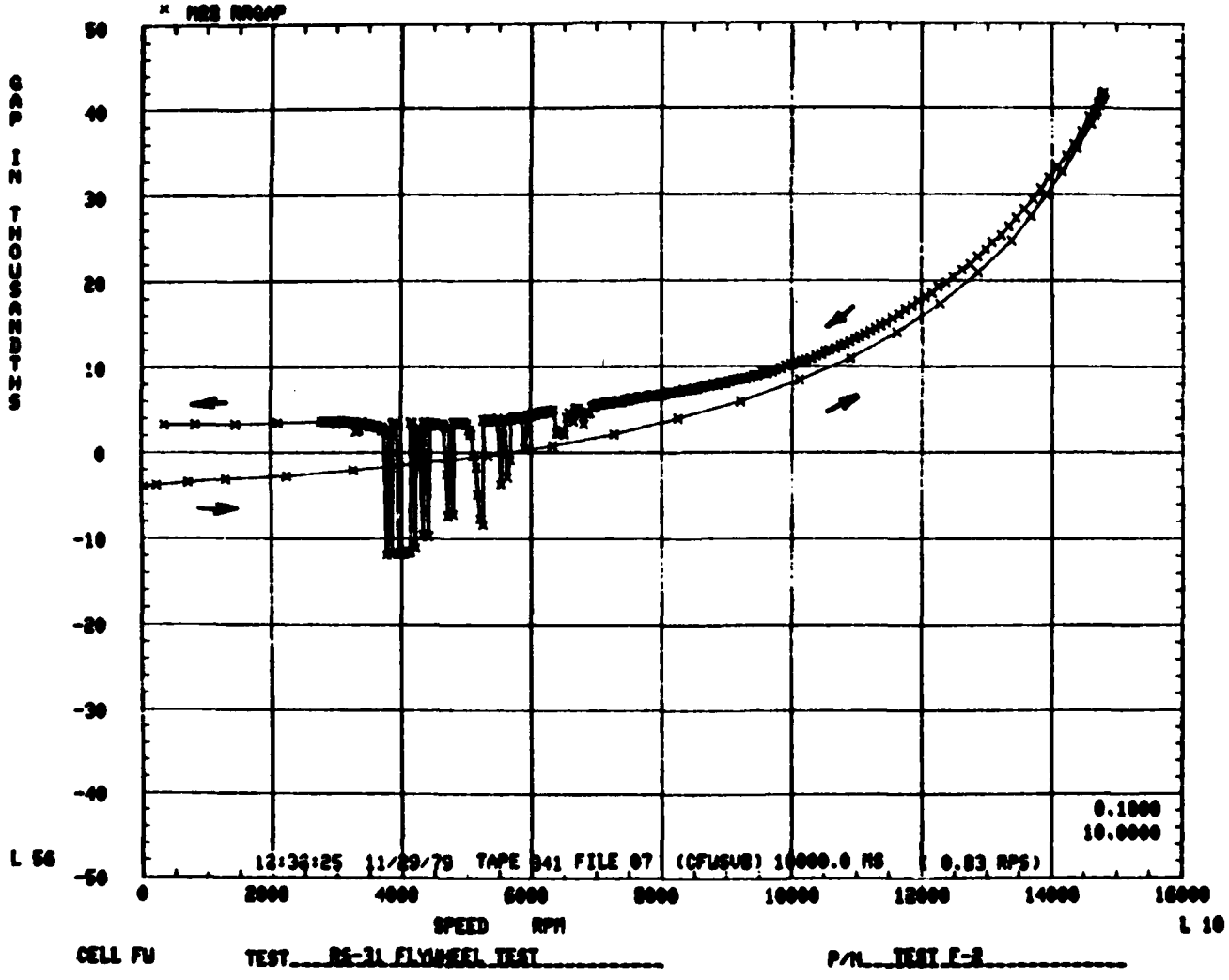

M57 BIOP
M22 FOP
M23 AOP
M24 GBOP
M23
M22
M57
M24
600
500
400
300
200
100
0
-100
0
500
1000
1500
2000
2500
3000
TIME - SECONDS
0.1000
2.0000
L 12
13:38:25 11/22/79 TAPE 341 FILE 07 (CFUM22) 2000 0 MS (0.83 MPS)
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST E-2

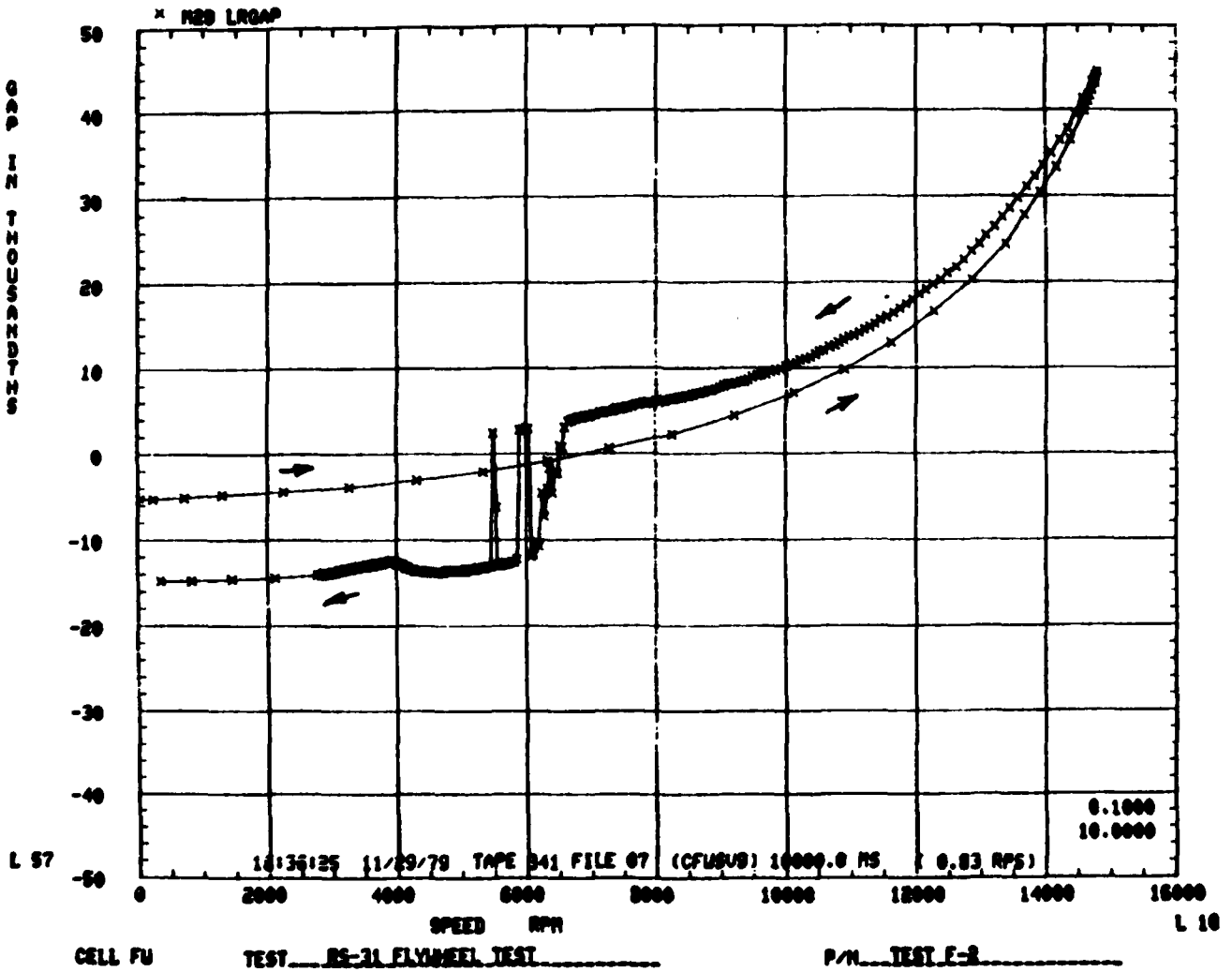


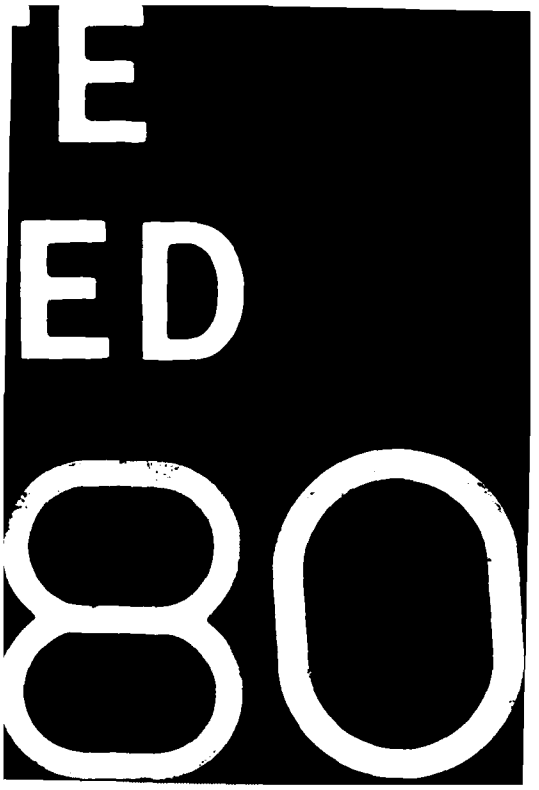
CELL FU TEST RS-31 FLYWHEEL TEST P/N TEST F-2


LN8NST
△ M71
× M9 LFCAUT
○ M10 AOT
□ M70 RESUOT
TEMPERATURE DEG F
320
275
250
225
200
175
150
125
100
75
50
25
0
M71
M10
M70
M9
0.5000
2.0000
L 52
18:36:25 11/29/79 TAPE 341 FILE 07 (CFUN8) 2000.0 MS (0.83 RPS)
0
500
1000
1500
2000
2500
3000
TIME - SECONDS
CELL FU
TEST 95-31 FLYWHEEL TEST
P/N TEST E-2


× MBB RFGAP
GAP IN THOUSANDTHS
50
40
30
20
10
0
-10
-20
-30
-40
-50
0.1000
10.0000
L 54
13:36:25 1:/09/79 TAPE 341 FILE 07 (CFUSU6) 10000.0 MS 0.83 RPS)
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
L 10
CELL FU
TEST BS-31 FLYWHEEL TEST
P/N TEST F-2


* MBB RROAP
GAP IN THOUSANDTHS
50
40
30
20
10
0
-10
-20
-30
-40
-50
L 56
0
2000
4000
6000
8000
10000
12000
14000
16000
L 10
SPEED RPM
0.1000
10.0000
12:36:25 11/29/79 TAPE 941 FILE 07 (CFUSUB) 10000.0 MS (0.83 RPS)
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-8


× M20 LRGAP
GAP IN THOUSANDTHS
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
2000
4000
6000
8000
10000
12000
14000
16000
SPEED RPM
L 57
L 10
0.1000
10.0000
CELL FU
TEST RS-31 FLYWHEEL TEST
P/N TEST F-8


E
ED
80